SCIENTIFIC AMERICAN SUPPLEMENT No. 480

Scientific American Supplement, Vol. XIX., No. 480.
Scientific American, established 1845.

NEW YORK, MARCH 14, 1885.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE DEFENSE OF PORTS BY MEANS OF ELECTRIC TORPEDOES.

At the present time, when most powers are endeavoring to extend their colonial possessions, navies are assuming more and more importance, and electricity is becoming one of the principal auxiliaries of all armaments. We have many times pointed out the services rendered by electric lights upon vessels or in fortifications, and not long ago we gave an account of the experiments performed at Brest, by order of the Minister of the French Navy, on the defense of passes. But electrical processes, while they permit of surprises being avoided, and render it possible at night to fire guns of large caliber that are used for coast protection, furnish still other means of destruction that are capable of annihilating the most formidable iron-clads in a few instants.

The torpedo is a weapon so much the more formidable in that, with recent electric improvements, it can be taken by hand, so to speak, to the point where the explosion is to occur. So when a port or accessible places along shore shall have been provided with a complete system of torpedo defense, fleets will be unable to force a passage to them.

According to the *Engineer*, it was in 1855 that the first floating explosives were employed, this being at the siege of Anvers, by an Italian engineer, who succeeded in blowing up a bridge over the Escaut. Governments then began on every side to study the methods of attack that gave so surprising results at slight expense and with no great risk.

Fixed submarine explosives and floating torpedoes were used up to the time when Captain Ballard, of the English army, proposed the construction of boats designed for carrying, launching, and steering torpedoes by means of electric cable connected with the base of operations.

A few years after Captain Ballard's system of maneuvering explosive apparatus had been devised, Colonel Lay, the inventor of the torpedo that bears his name, proposed a nearly similar method. He, moreover, has constructed and put in use a large number of torpedoes, especially in Russia and the United States, and his labors have demonstrated the possibility of producing torpedo boats that may be moved mechanically by means of an electric cable while connected with the base of operations.

Self-propelling torpedoes, capable of being steered, were confronted with one difficulty at the outset—that of finding a power to actuate them. Colonel Lay employed carbonic acid gas, a product not convenient to manufacture, especially on board an iron-clad, where all such preparation is, moreover, formally interdicted. The use of a gas or of compressed air offers serious inconveniences, and is not always practicable; so apparatus constructed on this principle can only be applied, in a certain measure, for the defense of ports, coasts, or coasting stations.

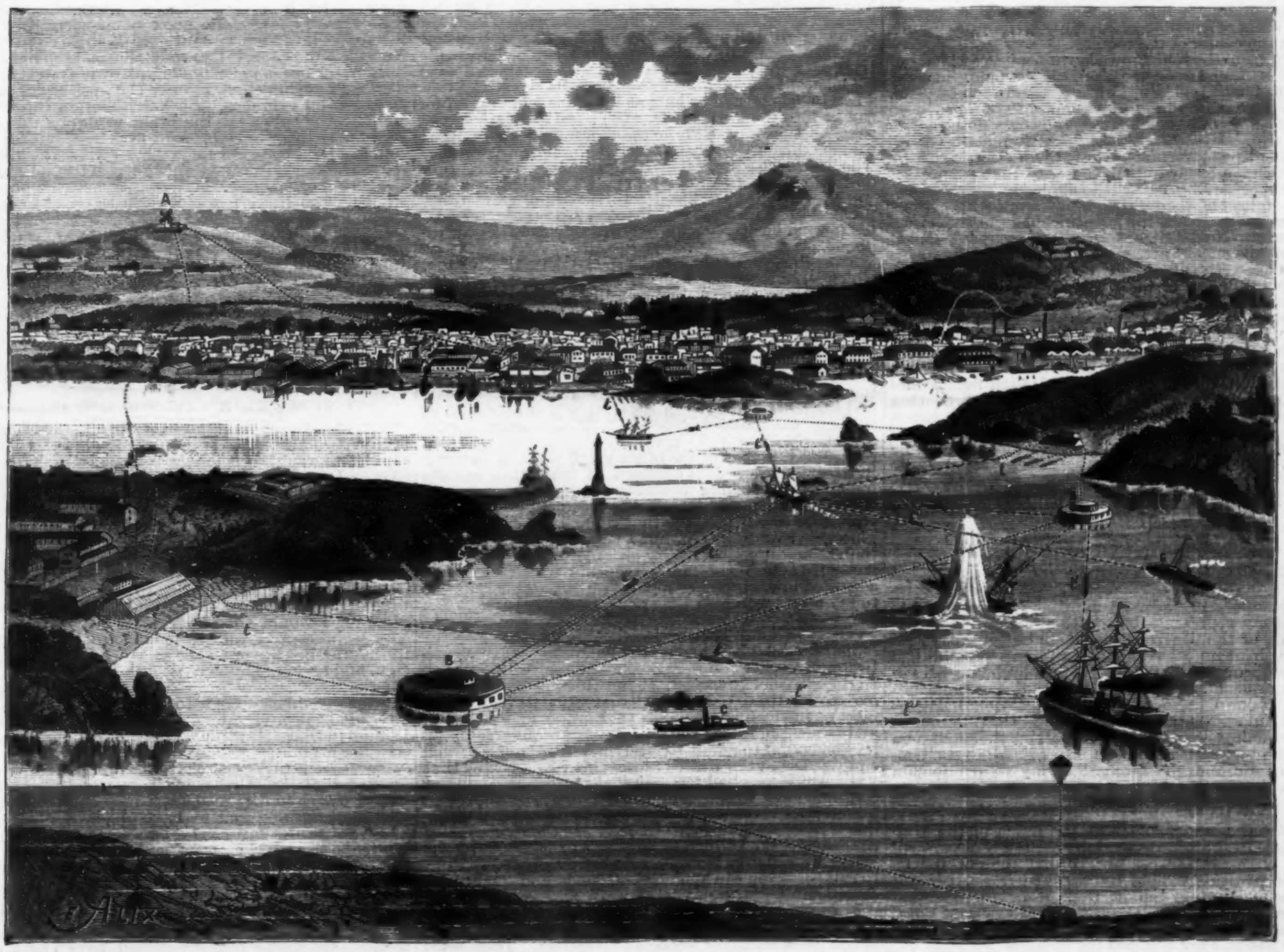
The fish torpedo (Whitehead's) must be launched from the base of operations in a given direction, its steering mechanism being arranged in advance in such a way as to direct the apparatus to the object to be destroyed. This machine certainly constitutes a remarkable weapon of the greatest power, but it is impossible to employ it with precision in a rough sea or in a current, and it is only in the vicinity of the point to be attacked that it can be used with any chance of success.

As it is almost always necessary to operate from a distance, one must have at his disposal apparatus of long range that are capable of being maneuvered, at any point of their travel, from the base of operations, so as to surely reach the object and explode at the moment most favorable to the attack. Such results can be obtained only with torpedoes that are self-propelling and capable of being steered.

In America, Mr. J. S. Williams has devised a system of torpedo boats and launching apparatus, as well as the various accessories for defending seaports, bays, coasts, and coasting stations; and the accompanying engraving gives a general view of a port in which all the works of defense are organized according to his plan.

The city is spread out at the foot of the hills that are seen in the distance; next comes the basin of the port; then, in front, is seen a jetty with a lighthouse that marks the level of the pass, and, on each side, the land that surrounds the port properly so called. The various points of the defense and their electric communications are indicated diagrammatically. Upon an elevation in the background is figured a wind-mill, A. It is in the interior of this that are located the dynamo machines that are designed to furnish the electric current. The conducting cables, which are indicated by dotted lines, start from A and connect with each other the three floating batteries, B B B, but the line, after reaching the first of these, passes to an earthwork situated to the right, and, after reaching the third battery, runs through still another casemated station, in order to complete the circuit at the starting point. There will be seen in addition, at C C, two torpedo boats that concur in the general defense.

Our engraving represents a moment when an iron-clad and other ships of the enemy are endeavoring to force an entrance of the port in order to bombard the town. From the different points prepared for the defense, as we have just indicated, self-propelling and steerable torpedoes have been immediately launched, and are converging upon the vessels that are to be destroyed. The letters *t* indicate torpedoes that have started from the batteries stationed upon land, *t'* those that have been launched from the floating batteries, and *t"* those that have been launched from the torpedo boats. These various torpedoes are connected with the base of operations on each side of the pass by electric cables that unwind.



DEFENSE OF A PORT BY MEANS OF ELECTRIC TORPEDOES.

The vessels of the enemy, as soon as they approach the port, cannot fail to get into the circle of action of these various batteries of torpedoes, the radius of destruction of which is only limited by the length of the cable that is unwound, and this may reach about a mile and a half.

This system, then, as may be seen, constitutes a formidable means of defense, since it permits of having constantly in hand at the base of operations a method of exploding torpedoes within a radius of 3,000 square yards. Such progress made in the science of destruction is very astonishing, for formerly, with stationary apparatus containing the same charge of explosive material, it was possible to work destruction within a radius of only about fourteen square yards.

Self-propelling torpedoes launched from the coast may receive the requisite electric energy from the principal circuit extending along the shore, and coming from the prime source, whatever be the distance from the principal section or base of operations. The electric current may be produced by any natural force whatever, or by fuel, and be transmitted through the

principal circuit, with high tensions, to the secondary stations of the coast or to floating batteries that carry accumulators for storing up the energy. These latter may be so arranged that they shall be always ready to furnish power, and shall continue to receive a charge as long as they have not reached their limit of storage capacity. Interrupters are placed in the system of derived circuits in order to throw out the reserves when they are sufficient. There is a special device for preventing the current from returning from the stations to the source, and the passage of an excess of current into the circuit that embraces the accumulators is arrested automatically. Finally, the discharge circuits of the reserve stations may be connected with a line that shall furnish a current to the torpedoes or the vessels, so that these latter will not have to make returns to the port.—*La Lumiere Electrique.*

TORPEDO OBSERVING STATION.

AT the time of the last Austro-Italian war, in 1866, the Austrian Government made the greatest efforts to put its ports in a state of defense against an attack of the Italian fleet. Torpedoes in large numbers were sunk therein, and all the commandants of these maritime places were ordered to exercise very great vigilance.

The engraving on opposite page represents the post of observation, or of firing, where the employes of the military telegraph are stationed.

The torpedoes are placed in several concentric lines, quite near each other. They are sunk to a certain depth below the level of the water, and, at the surface, give no signs of their presence. Each of them is connected by wire with the post of observation, situated at a sufficiently high point on the coast to allow the port to be seen well. The room, which is quite large, is dark. In the wall there is a lens that faces the port. The luminous rays from the exterior traverse this, become refracted, and pass into a prism, which directs them upon a sheet of ground glass lying horizontally upon a table in the center of the room.

According to the well known laws of optics, an image of the port is formed upon the glass. Black points marked upon this image indicate the exact site of each torpedo, and all these points bear numbers that are reproduced upon the keys of a key board. It is only necessary to press one of the keys with the finger to put the corresponding torpedo in connection with an electric battery through the intermedium of the wire that connects it with the port, and to cause it to explode.

One employe of the telegraph never takes his eyes off the glass upon which the faithful image of the port is reproduced. No detail, no movement, escapes him. If a ship of the enemy attempts to approach, its image appears upon the glass, and, at the moment it passes over a point indicated upon the latter, a simple touch of the key corresponding thereto causes an explosion, and destroys the vessel.

These torpedoes are sunk to a sufficient depth to allow ships of the port to move around without having anything to fear. It is probable that it was due to a knowledge of the danger that the Italian fleet would have experienced in attacking the Austrian ports, that the latter were protected against all surprise.

Arrangements analogous to those just described are now adopted by most of the navies of Europe.—*La Nature.*

THE MECHANIC ARTS ABROAD AND AT HOME.*

By COLEMAN SELLERS, C.E.

MR. PRESIDENT AND MEMBERS OF THE FRANKLIN INSTITUTE:

Our Secretary has advised me that I am expected to speak of my representation of this society at the Tercentenary of the University of Edinburgh, to touch perhaps on technical education, and say something of my impressions of the state of the mechanic arts in Europe as compared with the state of the same arts here. Any one of these subjects might, without being exhausted, fill all the time I dare take in the programme of this evening, so my remarks on all of them must be of the most superficial nature. In regard to the University of Edinburgh—I found on my return home a paper which I will read to you:

UNIVERSITY OF EDINBURGH, May, 1884.

Sir: We, the undersigned, in the name of the University of Edinburgh, respectfully request that you will convey an expression of our cordial thanks to the Franklin Institute, Philadelphia, for their courtesy and kindness in deputing you as their delegate to attend the Tercentenary Festival of the University of Edinburgh, and for the congratulatory address with which, by your hands, they honored the occasion.

Owing to the friendly co-operation of the Franklin Institute, Philadelphia, and other celebrated societies, the Tercentenary Festival became the greatest inter-academical and international gathering of distinguished men that, perhaps, the world has hitherto seen. A grateful memory of that illustrious assemblage, and of those who composed it, will ever be cherished by the University of Edinburgh.

We have the honor to be, sir, your faithful servants,

JOHN INGLIS, *Chancellor.*
STAFFORD W. NORTHCOTE, *Rector.*
A. GRANT, *Principal.*

Professor SELLERS, etc.

I have already reported to the Board of Managers of the Franklin Institute fully as to the performance of my duty of representing this Society at the recent Tercentenary celebration of the University of Edinburgh. It is perhaps not out of place now, however, to say that it was with feelings of sorrow that I took the place of Mr. Frederick Ransome, who had been appointed delegate, I being named as alternate. Domestic affliction was weighing upon Mr. Ransome, and he could not undertake what would have been great pleasure to him under other circumstances.

I promised him that I would tell you that it gives him pleasure to attend to such matters for the Institute as are intrusted to him in London, and that he deeply regrets his inability to act as the representative of the Franklin Institute at the Edinburgh Tercentenary. I need scarcely say that I assured Mr. Ransome that we fully appreciated all that he has done for us.

You have all heard of the many notable persons who collected to do honor to a university that has become celebrated during the three centuries of its life. The good people of Scotland living in the beautiful city of Edinburgh spared no pains to render the stay of the delegates very pleasant. Agreeable as this attention was, it rather prevented any social intercourse among the visitors, and the only chance to see those who were present from many noted colleges and learned societies in all parts of the world was at the dinners and entertainments prepared for that purpose. There, one could hear such men as Professors Von Helmholtz, Virchow, and Elize, Count Ferdinand de Lesseps, Professor Pasteur, besides a host of notable men from the institutions of English speaking countries. The most imposing ceremony was the presentation of the delegates to the representatives of the University of Edinburgh. On some of the most noted the degree of LL.D. was conferred at the same time, and this presentation afforded the chance to connect each in person with the name he bore. At the banquet, Earl Rosebery told the story of the college when proposing the toast "The Lord Provost, Magistrates, and Town Council of Edinburgh." For it was their predecessors, three hundred years ago, who founded this college without the aid of king or noble. As the speaker remarked, it was well the king gave none of the help he had promised, as he had nothing to give. Had he bestowed aught on the University of Edinburgh it would have been placed in the position of a receiver of stolen goods, for the king could only have given by robbing others. It was the people of Edinburgh who aided and supported the University, and to it flocked students from all parts of England and Scotland. Those came to it who could not enter the older colleges, for in it alone, among all, was there no sectarian qualification needed for entrance. The poor student bearing his bag of oatmeal for his winter support passed the house of John Knox, on Cannongate, and perhaps bought his cheap books at the shop of Allan Ramsay on High Street. Now, as then, no question is asked of him who enters and pays his modest fees. Through the years he can study, and when he has tarried as long as his purse will permit, he can go into the world and use the mind food he has consumed. It is only when he asks for a degree that he is examined to see if he has earned it. Very many of those who have been educated in the University of Edinburgh, and who in after years have made their mark in the world, have gone to that life work without graduating, perhaps to be honored by complimentary degrees when distinction has been achieved without the aid of a diploma.

After the foundation of the University of London, which is, like that of Edinburgh, free from sectarian requirements, there was some falling off in the attendance at the University at Edinburgh, the English institution taking its share of students. This, however, did not long continue, and the attendance in Edinburgh is now over 3,000, more than half being students in the very excellent schools of medicine. New and commodious buildings are being added to the college, and the chief industry in Scotland's ancient capital at this day seems to be education. The direction of education, so far as the University of Edinburgh is concerned, is like that of the other great seats of learning in Great Britain. It is confined to what they call the humanities; teaching the natural sciences, as in our technological institutions, is not yet much advanced in Great Britain. It is true that there is a chair of engineering at Edinburgh, but I think it is more in name than of any practical utility as a means of teaching. I mean there are not many students who seek to be educated in engineering at that school. This leads me to say a few words on

TECHNICAL EDUCATION.

Sir Lyon Playfair, at the annual dinner of the Institution of Civil Engineers in London, answering, with Earl Granville, the toast, "The Chief Seats of Learning of the United Kingdom," said that he had visited most of the technical schools of Europe and America, and he complimented the schools of our country, saying he was bound to admit that he had seen none so well equipped as in the United States; his version being that "the Americans had foreseen that protection could not continue long to exist in their country, so they had established technological schools to meet the consequent competition of free trade." He then mentioned the Guild School which is starting in London, near the South Kensington Museum, and briefly alluded to work that is being done in Manchester, Leeds, and some of the other manufacturing towns.

I cannot say that I accept the interpretation given by Sir Lyon Playfair as to the reason of the foundation of the great scientific schools of America. They seem to me to be the outgrowth of protection, the outgrowth of the advance in the trades brought about by protection and made necessary by the extended system of public education that has so long obtained here. Compulsory education is now being introduced into Great Britain, and is yet uncertain as to the best method of feeding the waters of the springs of learning to the young spirit thirsting for the draught, and at the same time to force it judiciously on those who have a hereditary distaste for such mental nourishment. It is not well for me to say overmuch about what is being done in teaching the sciences to the masses in Great Britain, but in Manchester and elsewhere I have seen some well fitted schools. I have seen rooms fitted with spinning machinery close to the drawing school. I have seen where the art of dyeing is taught under the name of chemistry, where weaving too is taught, and all this in a city where the chief industry is the use of the spindle and the loom. Now, with all due deference to the earnest men who have instituted these schools, I must say to them, if the sound of my voice through the reporters this evening is to reach over the three thousand miles of water that separate us, that it will in time be found that trades must not be taught in schools that are intended to educate the masses. I doubt if they can be so taught to advantage. Technical education, to be of the greatest advantage to the people in proportion to the money expended in the education, must be in the direction of "instructing without constructing." In other words, it will be found that the hands and eyes must be trained in the underlying principles. The use of tools must be taught as a means of educating the hands and the mind at the same time; but not in teaching or restricting the teaching to some of the few trades that use those tools in common; and I would restrict the teaching to the use of hand tools in the lower schools. Drawing is being taught in a very thorough manner in many of the schools in Great Britain, and many of those schools are directly attached to factories and workshops.

Much is said about a great town that has sprung up near to Chicago, which is wonderful as showing how a dreary waste of swamp land can be reclaimed and made the habitation of a large number of active workmen engaged in one trade. The counterpart of this can be seen on the beautiful banks of the Aire, in England. Here, Sir Titus Salt founded years ago, at his factories, the town of Saltaire, with many streets full of good stone dwellings, with large and commodious buildings for schools and public entertainment, with good pavements on the streets, such pavements as would put to shame the streets of this city of Philadelphia. An ample library is at the service of all the operatives, and the drawing school is conducted on the best principles of training the hand and eye and teaching habits of close observation. It was a treat to visit this place and see the neatness that prevailed, and to feast the eye on the brilliant verdure of the beautiful park that skirts the Aire, and to stand on the handsome stone bridge that spans the water close to the green fields, and to see the three thousand operatives trooping back to work from their dinner, looking contented, well-dressed, and with faces indicative of a higher education than is to be seen in many of the English manufacturing towns. In France, Germany, and in fact all the European countries I visited, there is a vast amount being done in technical education, so much so that it is becoming the general belief that the schools of Europe are now fitted to turn out full-fledged engineers. This is, I fear, a great mistake, and I think I can see plainly to what it is leading. I have seen a locomotive, for instance, that required for its construction a specification covering the leaves of a large folio book of many pages, telling the maker how each minute part is to be constructed, regardless of the facilities that the maker might have to construct economically on his own system of shop sizes. The cylinders seem to be the work of one scientific expert on cylinders, the valve motion the work of another, the boiler was the brain work of a third, perhaps; and the whole brought together into one machine—well, I confess I know not how, but looking like too much science and not enough practice. Engineers are born, not made. Mozart was a musician above all others before the science of acoustics was known or understood. Great engineers have achieved their greatness without the aid of schools, but we know not how much more easy they might have done so, and how much more they might have accomplished, could they have had the advantages of systematic technical education. No technical school can give experience and judgment; these come through work and close observation. The technical school must train the habits of thought in the right direction to avoid needless waste of energy, must teach how to work, not aim to take the place of skill and experience.

THE MECHANIC ARTS ABROAD AND AT HOME.

In regard to the mechanic arts, in the direction that my own profession would prompt me to look, I can only say that the subject is too great to be more than touched on. Landing on a foreign shore, modes of transport for man and matter first claim attention. A few days in Liverpool, for instance, and a ramble among the great docks and storehouses, gives food for much thought. First, the *very good* smooth pavements enable the horses to draw heavier loads with less labor than with us, and just here the contrast with our own city is so painfully humilating to us, that I dare not take the matter of pavements into thought this evening, for I would then have little else to talk about. Power cranes for handling goods either on the docks, in the warehouses, or on the road, are admirable in design, and are more numerous than with us. I cannot say that they are better than can be obtained here, but the people have come to require them more generally. Passenger elevators, or "lifts" as they are called in England, are slow, and far from equaling what we consider needful.

It was from Liverpool that the first passenger train, drawn by a locomotive, made its way to Manchester in 1829 or thereabouts. The English locomotive does not look like anything that we have under the same name. They are to my taste very handsome machines, well built, and neat in their freedom from extravagant ornamentation. The nature of the climate renders the need of protection to the men on the engine of less moment than with us, and the old "drivers" object to the more modern English locomotives, upon which small cabs are being now placed. The majority of English locomotives are inside connected, and have crank axles. They differ from the American locomotive in almost all essential points of construction. Plate or built up frames are universal, our bar frame not being used. The equalizing system universal with us is not attempted or deemed advantageous. The whole system of cars, either for passengers or freight, is different, and so far as the passenger service is concerned, is not to be compared with our own in comfort. Their light "coaches" are less steady than our heavier cars. To me it was always a delight when on one or another road I found the Pullman service in use, and yet I have been alone in a fine "drawing-room" coach while the ordinary, small, stuffy first-class coaches were filled with the natives, who prefer their exclusiveness, I presume. As the locomotive department is so different in its conduct and its output from our own, one naturally notices the difference, and it will be well perhaps to confine my remarks to this subject, or at least to make it more prominent than any other. In the first place, the manufacturers of locomotives cannot establish types and make them for sale in quantities. Each road has its own type of engine, and the builder must have his contract and be supplied with specifications before he can begin to work. On the other hand, the great roads of England employ talent of a high order in their locomotive department, recognizing the importance of a well designed and interchangeable system of service, and the influence of the superintendent of locomotives extends over all parts of the road where mechanical skill is required. The engine and the track are so intimately connected that they need be treated as a whole. Familiar as I was with the difference between the American and the English locomotive before I went

* Abstract of remarks made at the stated meeting of the Franklin Institute, Nov. 19, 1884.

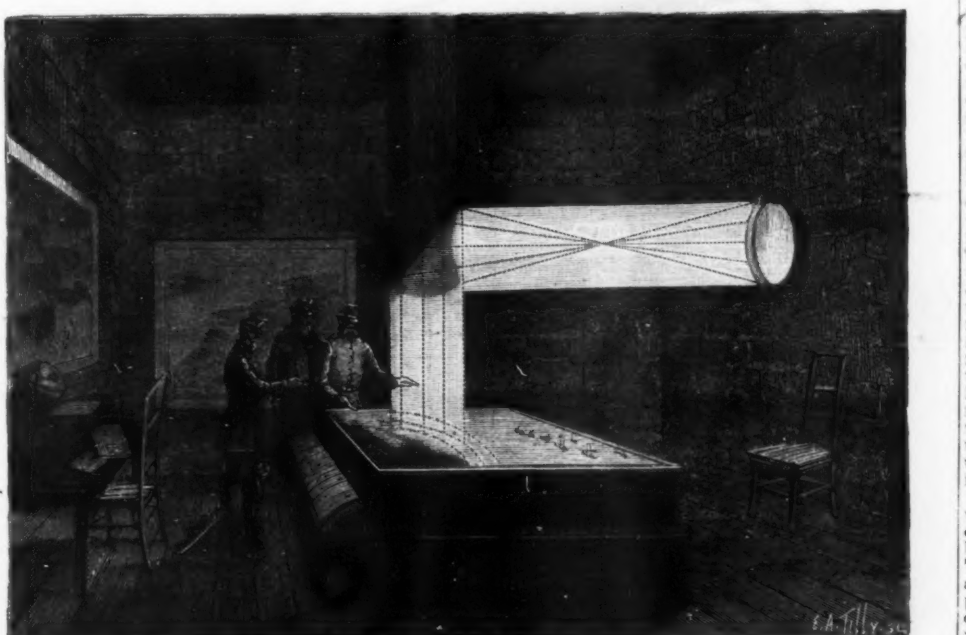
abroad, I naturally turned my attention to the more recent developments in engineering in that direction. There are many great corporations controlling lines of travel in England, and it would be invidious to comment on one more than on another, as so much good work is being done by all.

On the London and Great Western, however, there has been attempted so radical a change from former practice that I may well take the work of its Locomotive Superintendent, Mr. Francis W. Webb, as the "example" this evening. Mr. Webb has compounded his engines, and he has kindly furnished me with very good photographs of his new engines, some of which I will show you this evening by means of the lantern on the screen. On my second visit to Crewe, where are the chief shops of the London and North-Western Railroad, I had the pleasure of riding on the Dreadnaught, the last of the perhaps fifty compounded engines that Mr. Webb has built. It ran well, steadily, and was as readily handled as any ordinary locomotive of the old type. We made sixty miles an hour up the heavy grade out of Crewe, and came down the same incline at what was said to be seventy miles an hour. The Dreadnaught has two pairs of driving wheels, the hind pair of wheels being on a straight axle, and the cylinders connected with them being outside the frame—what we call outside connection. The cylinders are set well back on the engine, and the valve motion is that known as the "Joy," which dispenses with eccentrics, gets its motion from the connecting rod, and obtains the lap and lead from the cross-head. So far as I have now described the engine, it is as if it had but one pair of wheels on one axle, and a pair of cylinders to actuate that one pair of wheels. The forward drivers are placed on a crank axle, there being one crank only, in the middle of that axle, and to this is connected a rod from one single cylinder, placed immediately below the smoke-box; the front cylinder head being flush with the end of the smoke-box. This one cylinder operating the forward pair of drivers has an independent valve motion, and drives the front wheels, without any reference to the hind ones, so far as rate of revolution is concerned. This one cylinder is much larger than the cylinders that actuate the hind pair of wheels; it sheets out on an angle and riveting by power around the door hole, and swinging the door inward toward the fire in place of opening it out. He also dispenses with the bottom fire-box ring or "mud ring," and carries the water space in under the grate with an ash hole, like the fire-door, in the bottom of the box, and also one draught-hole low down on the vertical front face of the box.

A too hasty ramble through the shops of the London and Great Western road at Crewe was instructive, and there I had the pleasure of seeing a restored Trevithick high-pressure engine bearing date 1808, found by Mr. Webb in a junk shop in London, and saved by him from the hammer of the scrap buyer. This engine will perhaps soon rest in the South Kensington Museum, along with the old engine of James Watt and the Headley locomotive, and the other samples of the skill or ingenuity of the early mechanics.

I am told that there is now a movement on foot to build a monument to the memory of Trevithick, and to found scholarships in his name. I deposit with the secretary, this evening, pamphlets fully explaining this matter. I cannot say that we can indorse the claim of Trevithick's admirers that he was the first inventor of the modern high-pressure steam engine, as we believe that our own citizen, Oliver Evans, preceded him by many years. In those days the interchange of thought between the two countries was not very easy, and the most favorable light in which we can view Trevithick's claim is that he reinvented the high-pressure engine of Evans without taking the idea from him. One of the most interesting studies in mechanical progress that is possible in England and on the continent of Europe is in the direction of typical machines, the progress of invention being manifest from the oldest machines being still in use. This is instructive, but does not accord with our ideas of progress. New machines that can do more and better work should drive the old, crude contrivances into the scrap heap and into museums.

The museums are indeed rich in mechanical curiosities. In Edinburgh, Prof. Archer, having charge of the Museum of Arts and Sciences, has a number of workmen in a shop equipped with good tools, making large sectional models of important machines. He had just finished a model of the Headley locomotive, and I now deposit in the Institute the printed description of this model as furnished by Prof. Archer. In Birmingham I was in the private workshop of James Watt. Mr. Geo. Tangye now lives in the Watt mansion, and keeps intact the place where the great mechanic spent the last working days of his life. The coals placed there by his own hands still rest in his little furnace, and his leather apron, the apron worn by James Watt, lies on his turning lathe.



A TORPEDO OBSERVING STATION.

is, we will say, thirty inches in diameter; is in fact so related in size to the pair of cylinders that the steam that is exhausted from them enters this one cylinder at, say, forty pounds pressure, while the boiler pressure that gives the steam to the first pair is 180 pounds. No steam can reach the large cylinder that has not passed through the two smaller ones. The reversing machinery of the two separate sets of engines are connected, so that reversing one reverses the other.

I have said that Mr. Webb has about fifty of these engines on his road. They are also being tried in France. The inventor claims for them great economy over the old type of engines, of the best construction, and he is encouraged by his company to go on with the experiment. As yet they have not been tried here. I have seen the design of the system adapted to our construction of locomotive, that is, to the bar frame engine. From this room I will say to Mr. Webb that what is now wanted to influence the introduction of the engines here is mainly some exact figures as to economy, not as compared to what other engines on his road have done, but the foot-pounds of work as measured on a dynamometer car (such as is used on the Pennsylvania road), per pound of coal consumed. I think Mr. Webb has already undertaken to furnish this information, and we wait its publication before accepting the invention as an improvement over our practice. Here he will meet with the prejudice against the crank axle. The crank made by Mr. Webb is not so objectionable as the old form of double crank axle. He makes a well-hammered straight axle, and then by hydraulic power bends it into a simple crank with easy curves from the straight part. All the early locomotive service on the Grand Trunk Railroad, of Canada, was inside-connected, with cranked axles, and the fearful breakage of these in the severe winter weather of Canada soon compelled the abandonment of the system. It does not follow that severe cold makes the axles more brittle, but it makes the roadbed less elastic, and the hammering of the engine over the unyielding track is more severe on such pieces of machinery. I would like to comment very favorably upon many good points in the mechanical construction of Mr. Webb's engines; on the mode of making the fire-door holes, flanging both

In the transmission of power by means of belts, as compared to gearing, the practice in America has long been in advance of other countries. The wide first driving-belts, common in our mills, are not to be seen in England, but a change is now under way in that direction, and, as is often the case when a new system is pushed, ultra novelties are adopted. A system is now obtaining in England of using hemp ropes as first drivers. The fly-wheel of the engine is grooved, and from four to five ropes of about one and a half or two inches diameter each are made to carry the power to the grooved driving pulleys on the line shaft. Five ropes running from one grooved pulley to another grooved pulley, with no means of equalizing the strain on each cord of the system, is not according to our ideas of good practice. One rope must do more work than the others, and will give out the sooner. I incline to the belief that one rope even acts as a retardent to the others. They give each rope ten horse-power work to do, and say they work well; but they have had as yet too few years of use to test their durability. I have been told that the ropes last several years. Compare this life with that of a good double leather belt as first driver in use for thirty years and as good, almost, as new. This is no uncommon thing in our practice. We, in the design of machines, are inclined to make all we can out of the belt power, doing as little as possible with the gearing.

It is no unusual thing abroad to see very heavy machines with trifling belt power. I have to show you, however, this evening some samples of very good belt made of links of leather, put together edgewise, like flat-linked chains. This form of belting is coming into very general use in England, and in the Health Exhibition I had a chance to see the electrical machines driven by this form of belt, as compared to ordinary leather belt, and the merit of the link belt was manifest in the smooth running and freedom from vibration or wave. The belt is strong and very flexible. I have been told that its driving power is no greater than that of solid belts of the same weight, but at high speeds the adhesion is greater from the belt not being so apt to carry air between its surface and the pulley.

Many months spent in a new country is not sufficient to constitute any one an unerring critic of the engineering ability of the people, as the circumstances that govern the engineering thought differ. We cannot use English facilities of handling our freight at the stations, because the construction of our cars is not the same, and climatic considerations weigh with us. I lingered long in England, among the kind friends who were so willing to show me all they could of their methods and their work, and can say but little about those countries where the people, as some one says, "labor under the disadvantage of not speaking our language." The two great engineering societies of England, the Institution of Civil Engineers and the Institution of Mechanical Engineers, accorded to your representative every opportunity to avail himself of what they could do in the way of showing the work and the men who have done the engineering work of that country. This was accorded as freely before he was elected a member of each, as after. To the many kind friends who made him feel at home in a foreign land, he sends his thanks. To you, who met many of the representatives from those countries at the time of the Centennial, he brings their messages of kindly greeting. Go where he would, even as far to the north as the railroads would take him in Sweden and Norway, he met those who remembered the kindness of Philadelphia in 1876, and who send to Philadelphians their best and warmest wishes.

HOW TO MEASURE THE EFFICIENCY OF STEAM.

WE state advisedly that the following article is rudimentary, and is intended for the perusal only of those who are not yet familiar with the laws of heat and motion. We propose to say here, for the benefit of our younger readers, and of men who have not the time to read text-books, a few words concerning the efficiency of steam at various pressures, which they may find useful in their daily practice; and this we are induced to do by the knowledge that erroneous opinions on the subject are held by many persons, probably because the questions at issue are not clearly, and we might say controversially, set forth in the books they have read; while others have in a manner refused to investigate or acquire information for themselves, because they have failed at the outset to master certain truths set before them by various authors, and this not, indeed, because the authors in question are wrong, but because it is hardly to be expected that such an article as this—which is intended to be just what searchers after information want—would form a chapter in a text-book on the steam engine; for it must contain too much and too little for a chapter in such a volume, seeing that it must deal on the one hand with the very rudiments of the science of heat, and on the other with the application of these rudiments in practice. Our hope that we can make things clearer than they are made in most text-books, is based not on the assumption that the books in question are to blame, but on the theory that we can supply, so to speak, concentrated information on a single section of a great whole, instead of dealing with that whole.

Heat is supposed to consist in the extremely rapid vibration of the particles or atoms of which bodies are composed. Thus, when a bearing becomes hot, the brass is supposed to be in a state of intense vibration. This vibration is not visible to the eye, being too rapid and too minute, but it can be felt by the hand, and produces the sensation of heat. Heat, then, is a kind or mode of motion. Everything in the world with which we are acquainted possesses some heat motion, even ice. The sensation of cold which is felt when a bar of iron is touched on a frosty morning is purely comparative. No doubt all our readers are familiar with the thermometer, which is marked from zero up. Zero is the temperature of a mixture of snow and salt; water freezes at a temperature higher by 32 deg.; water boils at 212 deg. It is sufficient to mention these things. At one time zero was believed to be the extreme end of the thermometer scale, and it was held that nothing could be any colder. It is, however, well known now that zero, instead of being at the end, is really at the middle of a thermometer scale of considerable magnitude, and it is concerning this negative end, as it is called, of the scale of temperatures that we wish to say something to our readers. Very little is known about it by those for whose special benefit we are writing.

It is possible in various ways to produce temperatures much below zero. In other words, it is possible to take the heat motion out of bodies, or to reduce their vibrations. Thus, for instance, if crystallized muriate of lime be mixed with snow, a temperature of 50 deg. below zero can be produced. Dilute sulphuric acid mixed with snow or pounded ice will produce a temperature of 23 deg. below zero. All temperatures on that end of the thermometer below zero have the negative sign — put before them. Thus the temperatures given above are written —50 deg. and —23 deg. It may be asked, Is there no such thing, then, as absolute zero? and the answer is that there is. No one has any practical experience of such a temperature. Chemists have got down to about —210 deg. only. It is not likely that zero can ever be reached on this earth, though it is not impossible that it exists in stellar space. By a series of masterly investigations which we cannot stop here to explain, is has been demonstrated that the absolute zero—the point of no heat—is —461 deg. of the Fahrenheit or ordinary English thermometer. We may be asked, What has all this to do with the efficiency of steam? We hope to make the connection clear in a moment. It is essential that our readers should understand that in what follows we are measuring our heat from a different point. The zero of the common thermometer might, indeed, be used, but only in a very clumsy and roundabout way. If a shaft is to be turned to various sizes, it is best to set off the position of each collar or journal by measuring from one end, not from a center punch mark made about half way up it. Absolute zero, then, is the end, so to speak, of the

shaft on which we shall have to mark out certain distances.

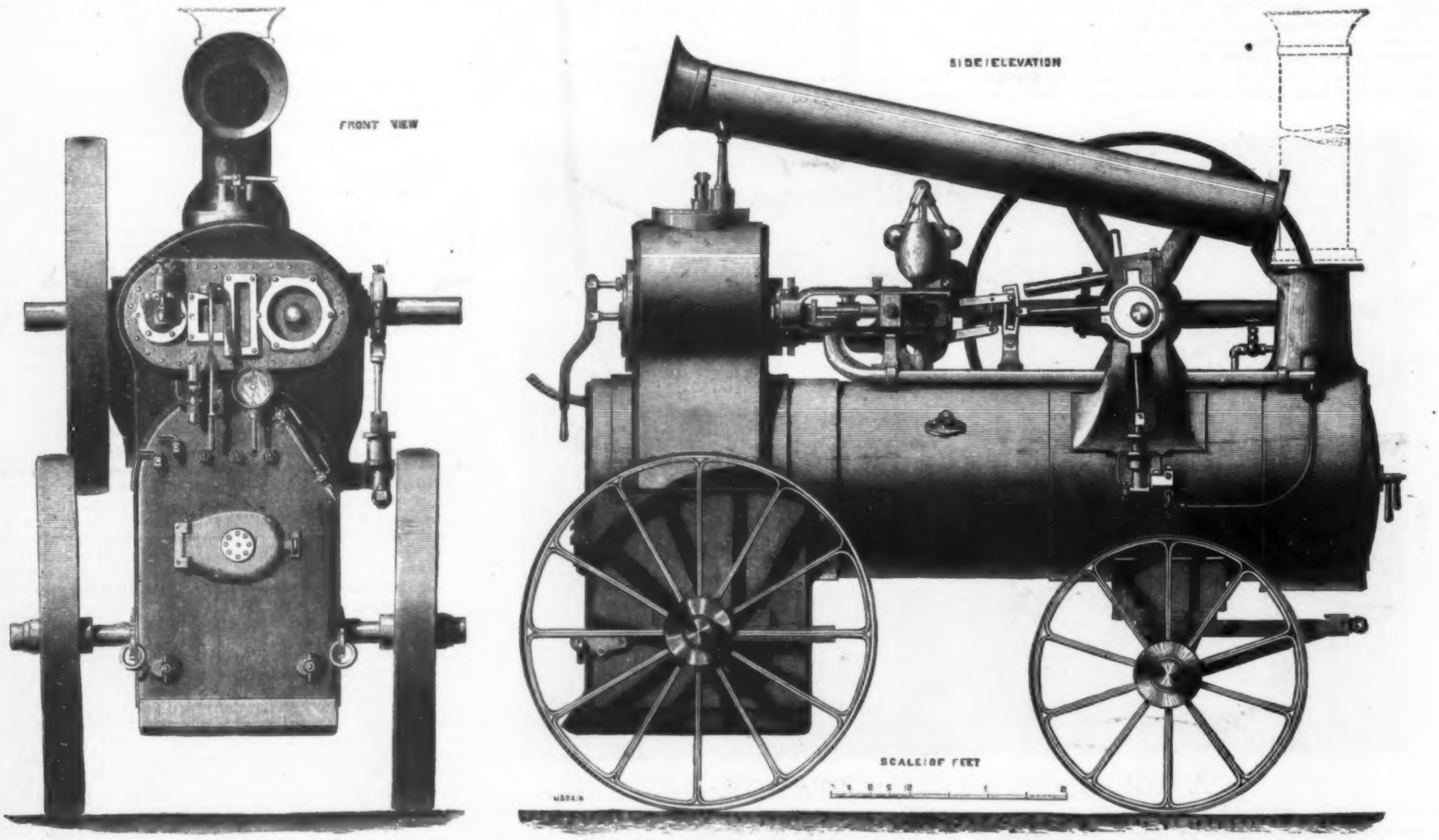
Heat can be converted into work, and work into heat; no one knows precisely how or why. But the exact amount of heat that is equal to a given amount of work was ascertained by Mr. Joule. It is equal to 772 foot-pounds per degree. It is known as "Joule's equivalent," and is written J in algebraical formulæ, with which, however, we have little to do here. When a pound weight is lifted 1 ft. high, a certain amount of effort is required, or work is done, and this is called a foot-pound. It is a measure for work just as a pint pot is a measure for beer. Now, the heat required to raise 1 lb. of water 1 deg. in temperature would, if all converted into work, suffice to lift 1 lb. 772 ft. high, or, say, three times the height of St. Paul's Cathedral, or 772 lb. 1 ft. high. It is essential that our readers should throughly master this unit, 772 foot-pounds per degree per pound of water. They will find it almost as useful as a 2 ft. rule. Before going further we must stop here to explain that in all our dealings with *water* the degree on the thermometer scale represents a standard unit. More heat is required to raise the temperature of water than to raise the temperature of any other known substance. Thus if we placed a pound of water and a pound of iron in, let us say, the same furnace for one minute, and then took them out and measured their temperature, it would be found that the iron was about nine times as hot as the water. The quantity of heat required to raise a pound of water one degree is, then, a unit with which the quantity of heat required to raise the temperature of all other bodies can be compared.

Now, the efficiency of steam, or its capacity for doing work, depends on the amount of heat which it contains, and which can be converted into the work to be done. Steam contains an enormous quantity of heat. Thus, if we take a pound of water at 32 deg.—

to warm up the metal instead of giving it up in the form of work. The gain to be had by expansion is simply this: if steam is not expanded in the cylinder, it will be discharged at nearly the same pressure as it entered the cylinder, and all the work which it could do—thanks to this pressure—would be wasted. To ascertain the effect of expansion is a very simple matter. Let the student obtain a table of hyperbolic logarithms; he need not trouble himself to find out what a hyperbolic logarithm is. Let him ascertain the number of times the steam is expanded, which he can easily do if he knows at what portion of the stroke the steam port closes, and the clearance. Then let him look out for the hyperbolic logarithm opposite this number, add one to it, and multiply it by the pressure in the cylinder when the steam port just opens and the crank is on the dead center—which is called the initial pressure—and divide by the ratio of expansion; the result is the average pressure on the piston for the whole stroke. For example, an engine has a cylinder 12 in. diameter and 2 ft. stroke, and the initial pressure in the cylinder is 60 lb., besides that of the air on the safety valve; so the absolute pressure—above a vacuum—is 75 lb. Steam is admitted to the cylinder for one-fifth only of the stroke, and is expanded four times—that is to say, at the end of the stroke it fills five times as large a space as it did at the beginning. Now the hyperbolic logarithm of 5 is 1·6094; to this we add 1, and get 2·6094. This we multiply by the pressure 75, and get 195·7050. This we divide by the ratio of expansion, namely, 5, and we get 39·14 as the average pressure, or, say, in round numbers, 39 lb. The area of a 12 in. piston is 113 square inches, and 113 × 39 = 4,407 lb. pushing the piston; from this we must deduct 113 × 15 = 1,695 lb., if the engine is non-condensing, or about 113 × 4 = 452 if the engine is condensing, for back pressure. In the first case the available push on the piston is 2,712 lb. If the engine makes

the precise quantity of condensing water discharged. There is, however, another way in which the relative values of different pressures of steam and expansions may be arrived at, and this brings us at once back to the statements made at the beginning of this article. We must again ask our readers not to trouble themselves about proof or explanation, but to take our word for it that the efficiency of a steam engine or other heat engine can be determined by the equation $E = \frac{T - t}{T}$, that is to say, let E stand for the efficiency or capacity for performing work of a pound of hot air or steam, T for the temperature at which it begins to work, and t for that at which it leaves off. Then if we deduct the lower temperature from the higher, and divide the remainder by the higher temperature, we get a fraction which represents the efficiency of the fluid, be it air or steam.* We are aware that this statement only applies with strict accuracy to steam which is quite dry and slightly superheated—steam gas in fact; but for the purpose of comparing two engines, the equations may be used without introducing any important error. But the temperatures used must be absolute; that is to say, measured from the absolute zero, and we have therefore to add 461 to the ordinary temperatures.

To give an example, let us suppose that an engine uses steam of 100 lb. absolute pressure—75 lb. load on safety valve per square inch—and expands it five times; then the pressure at the end of the stroke will be one-fifth of 100 lb., or 20 lb. Now, the temperature of 100 lb. steam is 328 deg., and that of 20 lb. steam is 228 deg. To each must be added 461 deg., and substituting these figures for the letters in the equation given above, we have $\frac{789 - 689}{789} = 0·128$. That is to say, if the whole of the heat in the steam had been converted



COMPOUND PORTABLE ENGINE. -R. HORNSBY & SONS, GRANTHAM.

that is to say, just on the point of freezing—and put it over a fire, it will require, say, a quarter of an hour to boil, and will absorb 180 units, or enough to do 180 × 772 = 138,960 foot-pounds, or, in round numbers, sufficient to lift over 61 tons a foot high. Keeping the vessel still on the fire, the water will all be boiled away in a little over an hour and twenty minutes, so that the steam takes off with it nearly five and a half times as much heat as sufficed to raise the temperature of the water from 32 deg. to 212 deg. The total quantity of heat put into a pound of water beginning at 32 deg. to convert it into steam of 212 deg. is 1,146 units, each unit, as we have just explained, representing as much heat as would raise one pound of water one degree; and multiplying this by 772, we get the astonishing quantity of 884,712 foot-pounds, or 395 foot-tons. All this work might be got out of a pound of steam, in an engine, if it were possible to prevent waste of heat in any way; and if the steam could be compelled to do work until it was all turned back into cold water. As this is impossible in practice, we can only try to get as much heat converted into work as possible; and the *difference in economy of fuel between any two or more engines will be measured by the quantity of heat which is turned into work, and by nothing else.* In other words, that will be the best engine which gets most work out of each pound of steam which goes into it.

We have shown that steam contains an enormous quantity of heat, so that we have, so to speak, a huge margin to draw upon. It is as though we had bags passing through our hands each containing a hundred sovereigns, out of which we could only take a few for our own use. It forms no part of our purpose here to explain how one engine can be made more economical than another. It must suffice to say that the great things to be observed are: First, to keep the cylinder hot; and, secondly, to expand the steam. If the cylinder is not kept hot, steam will part with its heat

100 revolutions per minute, we have a piston speed of 400 feet per minute, and $\frac{400 \times 2712}{33,000} = 32·8$ horse power. If, now, instead of expanding the steam we had allowed it to follow full stroke, we should have had $\frac{113 \times 60 \times 400}{33,000} = 82$ horse power. In this case five times as much steam is used to get 82 horse power as suffices with expansion to get 33 horse power. Let us suppose that with expansion 20 pounds of steam gave one horse power for an hour, then for, in round numbers, 33 horse power we would require 33 × 20 = 660 lb. of steam per hour. The non-expansive engine, using five times as much, or 3,300 lb. will give out 82 horse power, and $\frac{3300}{82} = 40·2$ lb. Thus, by expanding, we make one pound of steam do as much as two pounds will do without it; or, other things being equal, we make one pound of coal go as far as two.

We have said that part of the heat of steam is converted into work. The result is that less heat is sent out of the cylinder than came into it; and this fact supplies a ready means of testing the efficiency of any steam engine which is fitted with a condenser. It is only necessary to measure the rise in the temperature of the condensing water to ascertain what the engine is doing. Thus let us say that there are two condensing engines at work, and that each uses a hogshead of condensing water per minute, the power of the engines being the same, and that one has a temperature in the hot well 10 deg. higher than the other. Then this last is more wasteful of fuel than its fellow, because it is not getting so much work out of a pound of steam. Therefore more pounds of steam have to be used, and the condensing water is hotter. This method of estimating the efficiency of engines is actually employed by Messrs. Bryan Donkin and Co. The objection to its use lies in the difficulty of measuring with exactness

into work, we should have realized 1,000 horse power; as it is, we realize 128 only.

Now let us suppose that the initial pressure was 150 lb., and the expansion five-fold. Then the terminal pressure would be 30 lb.; the initial temperature would be 358 deg.; the terminal temperature would be 250 deg. Then we should have 358 + 461 = 819 and 250 + 461 = 711, and $\frac{819 - 711}{818} = 0·132$. That is to say, under the new conditions, out of every 1,000 horse power in the steam, we can only realize 132. Many persons have argued from such facts as these that the steam engine is a very wasteful machine. This is not the fact. The loss arises from the circumstance that we have first to make the working fluid steam, and then to throw it away into the air or into a condenser. A good steam engine is as efficient as any other heat engine. In a hot air engine we have the fluid ready made for us, and the waste might be very small; but air is a very inconvenient working fluid, and this militates against its use.

If our readers have followed us, they will find that we have supplied them with a tool, by the aid of which they can always ascertain what is the theoretical advantage of any given pressure of steam and ratio of expansion; and they can, when they hear the advantages of high-pressure steam talked of, find out for themselves whether there is or is not anything in it. They will see, for instance, from the example we have quoted above, that simply augmenting pressure, leaving the range of expansion unaltered, is directly productive of loss instead of gain. In conclusion, we will only say that any of our readers who desire to ascertain the reason why of what we have said—and we hope they are not few—will find, if they have time to read it, an

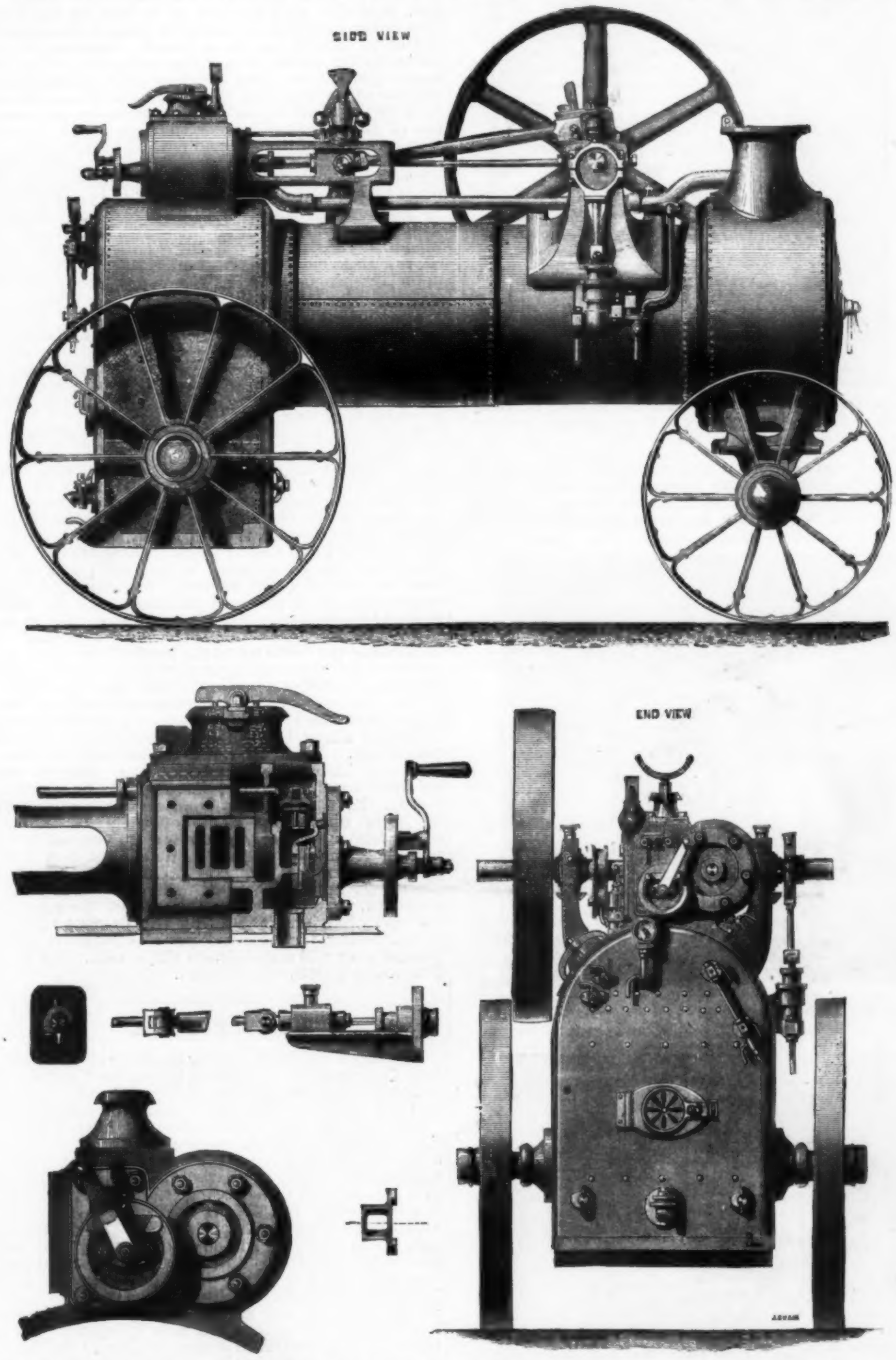
* The maximum amount of work that can be got in a heat engine out of any gas or vapor is $772 \frac{T - t}{T}$.

immense amount of information in Goodeve on the Steam Engine, a book of moderate dimensions and reasonable price, which can be obtained through any bookseller.*—*The Engineer.*

RECENT PATTERNS OF PORTABLE ENGINES.

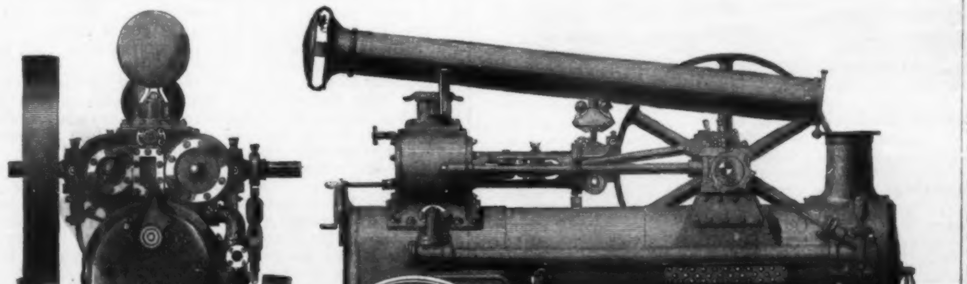
AT the recent annual Agricultural Exhibition of the Smithfield Club, London, several styles of traction engines were shown, of which we here give examples, namely, a three horse power engine by J. T. Marshall & Co., Nottingham, and a compound engine by R. Hornsby & Co., Grantham; both engravings are from *The Engineer.* We also give an engraving of a 16 H. P. portable engine by Marshall & Sons, of Gainsborough, concerning which *Engineering* says:

The compounds shown by Marshall, Sons & Co., of Gainsborough, comprise one of their eight horse "underneath" semi-fixed engines of the "B" type, and a sixteen horse compound portable engine of a new pattern. In this engine, of which we give an engraving, the two cylinders, with the slide valve chest, intermediate receiver, and stop valve chamber, are combined in one casting, on the top cover of which the double spring safety valves are arranged. Circular bored crosshead guides are used in the place of the ordinary slide bars, one end of each of these guides forming the front cylinder cover and piston rod stuffing-boxes, while the opposite end is bolted to a wrought-iron bridge plate extending across the engine; this plate also carries the governors and the automatic expansion gear, which is applied to the high-pressure cylinder. The engine is fitted with a multitubular feed-water heater as shown in the illustration, this heater consisting of a number of small brass tubes through which the feed water is made to pass in the opposite direction to the exhaust steam, which traverses the outside of these tubes. One end of the heater is bolted firmly to the smokebox to which the pump is fixed, the opposite end being free to move endwise to allow for any variation occasioned by expansion and contraction. The crankshaft carriages are bolted to exceptionally strong wrought-iron hornplates well riveted to the boiler barrel, the plummer-blocks sliding in dovetail grooves at the top of the hornplates, and being tied direct to the cylinders by strong rods, which take all the thrust and pull due to the working of the engine. The cylinders are $7\frac{1}{4}$ in. and $12\frac{3}{4}$ in. in diameter, both 14 in. stroke. The flywheel is 5 ft. 6 in. in diameter by 10 in. wide on the face, and the boiler is made for a working pressure of 140 lb. We notice that on this boiler Messrs. Marshall have abandoned gauge cocks, and have provided duplicate glass water gauges instead—a far preferable arrangement. The engine is speeded for 155 revolutions per minute, and is mounted upon wrought-iron traveling wheels and a steel plate forecarriage.



THREE HORSE POWER PORTABLE ENGINE.—BY J. T. MARSHALL & CO., NOTTINGHAM.

* Goodeve, Text-book on the Steam Engine. Illustrated, price $2. For sale at SCIENTIFIC AMERICAN office, New York.



SIXTEEN HORSE POWER COMPOUND PORTABLE ENGINE AT THE SMITHFIELD CLUB SHOW.—BY MARSHALL, SONS & CO., GAINSBOROUGH.

THE KRUPP WORKS AT ESSEN.

THE great iron and cannon founding establishment of Herr Krupp at Essen is constantly enlarging its space and *personnel.* In 1860 it contained but 1,764 workmen, and this number had increased by 1870 to 7,084, while at the present time it is over 20,000; if also the women and children dependent on the establishment are included, a population of no less than 65,381 is gathered together, of which 29,000 persons are actually living in houses belonging to the works. The various departments of the Krupp undertaking are eight in number, and embrace the workshops at Essen, three collieries at Essen and Bochum, 547 iron mines in Germany, mines in the north of Spain, in the neighborhood of Bilbao; the smelting furnaces, a trial ground of 17 kilos. at Meppen for proving cannon, together with others at different places with an area of $7\frac{1}{2}$ kilos. There are 11 smelting furnaces, 1,542 puddling and heating furnaces, 439 steam boilers, and 450 steam engines of 185,000 horse power. At Essen alone the works connected with rolling stock comprise 59 kilos. of rails, 28 locomotives, 883 wagons, 69 horses, 191 trolleys, 65 kilos. of telegraph line, 35 telegraphic stations, and 55 Morse apparatus.

THE RAILWAY AND PORT OF REUNION ISLAND.

IT was toward the middle of the 17th century that the French founded their first establishment at Madagascar, and took possession of Bourbon Island.

The new East India Company, which owed its origin to Colbert, developed the culture of the sugar-cane, coffee plant, and various spice trees in these colonies, and commerce quickly grew there, but the want of ports capable of sheltering ships against the tempests that frequently occur in these regions was at this epoch a great obstacle in the way of Bourbon's prosperity. The governor of this colony then took possession of the neighboring island, Mauritius, which he named the Island of France. These two magnificent colonies enjoyed an increasing prosperity up to the liquidation of the India Company. Afterward ceded to the royal domain, they were, later on, along with the Seychelles and Madagascar, united by a decree of the National Assembly into a single department. Bourbon then took the name of Reunion.

Captured along with Mauritius by the English in 1810, it was restored again to France in 1815, and since that epoch there has been a great development in public works, in institutions of credit, and in the culture of sugar-cane, which was for a long time its great source of riches.

The abolition of slavery in 1848, which was wisely prepared by a previous law that permitted the slaves to purchase their freedom, was far from proving a check to the culture of the sugar-cane, for plantations of this were organized with such activity that the island was unfortunately almost entirely divested of trees thereby, and all other cultures were either abandoned or transferred to the uplands. For the last twenty years, Reunion's prosperity has been declining. The ravages caused by cyclones, and those occasioned by the borer, an insect that attacks the sugar-cane, and the enormous development of the beet-sugar industry in Europe, have been the principal causes of this. Nevertheless, Reunion is of great importance as a station for the large packet boats that are now running to Australia and New Caledonia, and in view of France's present action in Madagascar, is of capital importance as a base of operations. While Mauritius, which is naturally endowed with magnificent ports and roadsteads, has also a railroad, Reunion saw her commerce more and more fettered through the difficulty of maritime operations. In order to prevent the entire ruin of this fine colony, the government happily resolved to construct a port and a railroad there. It was in 1872 that were begun the technical and commercial studies of these two projects, which in reality form but one, since, if it was indispensable to provide a shelter for vessels, it was none the less necessary to connect this port with the different quarters of the island. A society with a capital of five million francs ($1,000,000) was founded in 1878 for the execution of the important works of this enterprise, and was authorized to issue obligations representing a guaranteed governmental annuity of 1,925,000 francs.

The work was at once begun, and three years afterward the road was in running order. The line, which is of 3·28 foot gauge, starts from St. Denis, the chief town of the island, and runs along the shore in both directions, terminating on one side at Saint Pierre, and on the other at Saint Benoit.

While this road was being constructed around the island, the gigantic work of constructing the Pointe-des-Galets port was going on. The spot selected for this, situated on the west side of the island, presents

many advantages. The trade winds from the southwest do not, in fact, reach this point, since it is sheltered by the high mountains of the central part of the island. The plain of Galets is likewise somewhat sheltered against the cyclones that usually strike Reunion at the northwest. The shore here, which is a sort of delta at a mean height of 16 or 20 feet above the sea level, is formed of centuries of accumulations of bits of rock rolled by the Galets River. In the part selected for the excavation of the port it slopes seaward, at first gently, and then very steeply beyond depths of from 30 to 36 feet. Finally the Point is nearly in the center of the line of the railroad, and is consequently perfectly situated as regards the transportation of importand export goods. The port, which was excavated in the Point partly by manual labor, but mostly by means of powerful excavators, includes an outer port of square shape that communicates with the sea by a wide channel protected by two jetties, an interior rectangular basin, and two narrower basins that have been named "streets," and that are at right angles with the internal one. It will likewise include a dry dock, docks for merchandise, large workshops, etc.

The jetties which protect the entrance to the port have the form of arcs of a circle of 820 feet radius. They advance seaward as far as to depths of 50 feet, and leave a free opening of 328 feet between their walls. The artificial blocks of which they are constructed reach weights of from 110 to 120 tons, and were manufactured at some distance from the jetties, then carried to the spot and arranged regularly in place in order to form truly matched masonry, and not thrown pell-mell into the ocean as has hitherto been done in the case of most jetties. From this it will not seem astonishing that it was found necessary to devise an entirely new and special plant, and that the name of "Titan" was given the enormous rolling crane capable of effecting the laying of the blocks.

A beginning was made by constructing an abutment upon *terra firma*, and then there were successively laid courses of masonry formed of the enormous artificial blocks of beton that we have mentioned, and which were juxtaposed so as to give a width of 130 feet at the base and 50 feet at the top, and which were superposed in increasing number in measure as the work advanced

FIG. 1.—PLAN OF PORT OF POINTE DES GALETS (REUNION ISLAND).

seaward, and as the depth consequently increased. All the blocks, some of them trapezoid and others in the form of rectangular parallelopipedons, were constructed in rows in an immense yard provided with mechanical beton mixers, steam cranes, and a railway for the carriage of the materials. Above each row of blocks ran a rolling crane, quite analogous in form to those used at railway stations for unloading stone from cars, but much more powerful, constructed wholly of iron, and lifting each block in turn by means of powerful hydraulic presses. The block being lifted, the apparatus began to move along a double row of rails running along each row of blocks, and deposited the enormous mass (the lightest weighing 50 and the heaviest 120 tons) upon a 26-wheeled truck, which carried it to the jetty in order to be laid by the Titan. The latter consisted of a sort of large tubular girder, 16 feet in height by 148 in length, supported in the center by the piston of a hydraulic press. Upon the upper girders ran a car provided with windlasses and capable of moving from the rear of the Titan (where it took up the block brought by the truck) to the forward end of the enormous girder that projected over the water in front of the finished portion of the jetty.

The Titan as a whole, along with the block, represented a weight of 550 tons. This enormous mass was lifted by the central hydraulic press and revolved upon its piston, as upon a pivot, in order to deposit the block suspended from the car in the course of masonry that was being constructed. When each course was finished, the Titan moved forward upon steel wheels running upon large rails. When a cyclone or a strong tide-race occurred, the Titan was run back to *terra firma*.

The south jetty was finished at the end of 1881, and the north one in 1882. Since that epoch, and even during their construction, they have undergone the repeated assaults of several cyclones and tempests, and the manner in which they resisted them attests their solidity and the excellence of the principles according to which they were constructed.

While the jetties were being constructed, the work of excavating the port had been begun. When the completion of the former permitted of opening a communication between the sea and the basin of the outer port in course of excavation, the dredges, mounted and set afloat in the basin, began to excavate the channel, while a fleet of punts, towed by tugs, carried out to sea the material excavated by them. These dredges, which will finish the entire work in 1885, are provided with steel buckets of about 16 cubic feet capacity. Their engines develop a power of 50 horses, and the dimensions of their parts allow them to excavate the earth to a depth of 30 feet beneath the level of the sea. For excavating the earth up to the level of the water, excavators of the American type were used, these consisting of a large bucket or scoop of 35 cubic feet capacity, fixed at the extremity of a movable arm actuated by a steam engine, and the whole supported by a metallic car that advanced along the cutting in measure as the work progressed. With all these mechanical devices, the company had good reason to hope that it would be able to finish the port in 1883; but, unfortunately, the meeting of a compact mass of bowlders of large dimensions (some of them exceeding 35 cubic feet), and nearly damming up the outer port, notably retarded the work. But against new difficulties new processes are ever brought to bear. Compressed air apparatus, genuine diving bells of large dimensions, were sent last fall to aid in the removal of the rocky barrier. This latter the dredges succeeded in traversing through the use of dynamite, and the present year will certainly see ships enter the port of Pointe-des-Galets.—*La Nature.*

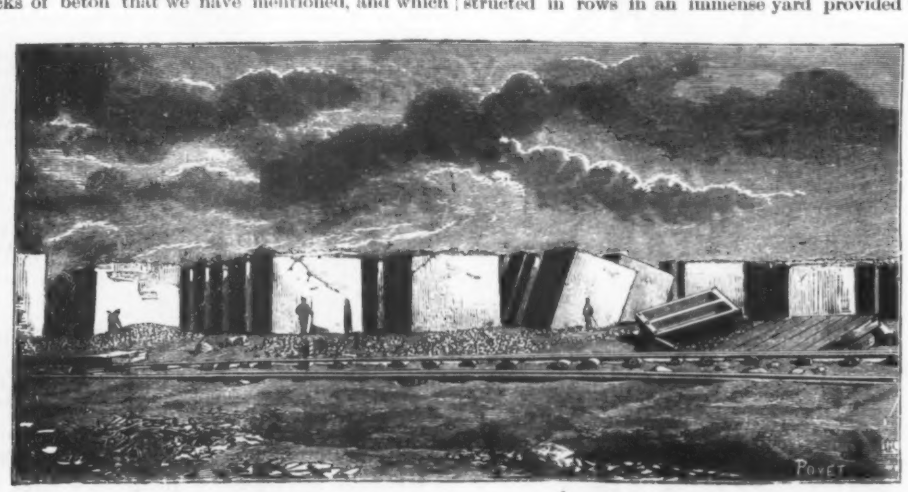


FIG. 2.—BLOCKS OF BETON.

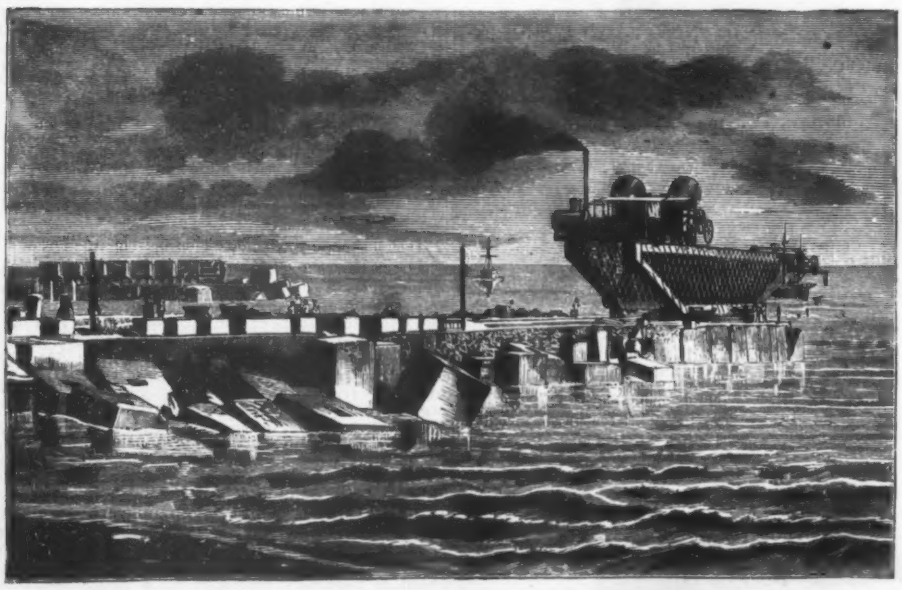


FIG. 3.—CONSTRUCTION OF THE JETTIES.

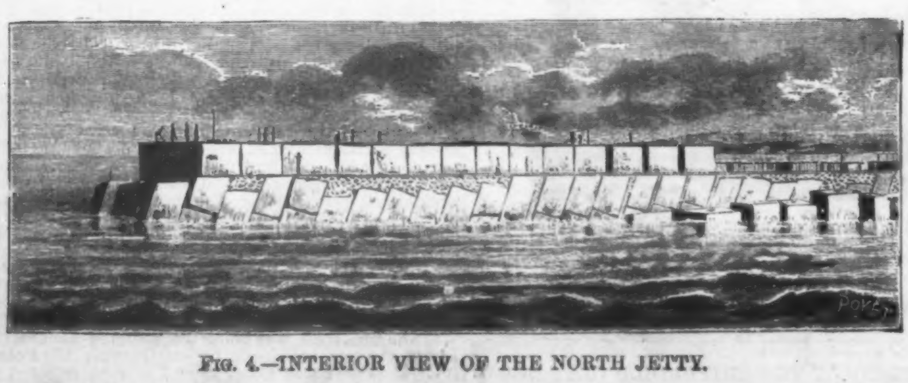


FIG. 4.—INTERIOR VIEW OF THE NORTH JETTY.

NATURAL GAS.

MR. JOHN FULTON, mining engineer of the Cambria Iron Company, in an address before the Cambria, Pa., Scientific Institute, on the geology of salt, petroleum, and gas, made the following remarks on natural gas:

The salt and petroleum industries have brought to light a third valuable element—natural gas—which, until recently, was regarded as a troublesome and undesirable associate. Immense quantities of this valuable heating and illuminating gas have been permitted to go to waste. In 1870, the gas from a well near Titusville was used for heating purposes. About ten years ago, it was used in Pittsburg for heating and steam-generating purposes. At Beaver Falls, natural gas has been used for five or six years in cutlery works, but lately the supply failed. During the past two years, its use has been greatly extended from the discovery of large producing wells at and near Pittsburg. Some of these have been utilized in supplying heat for the large iron and steel works in this section of the State.

The study of natural gas and its application to a wide range of useful purposes in heating and lighting have been fully initiated. It is difficult now to estimate the rapid expansion of this new industry or to outline the limits of its usefulness. The recent discovery of large gas-producing wells at Tarentum and vicinity has contributed to the assurance of a large supply of the gaseous fuel, but its persistency is yet on trial. Whether the life of gas-wells shall exceed or fall short of the life of oil-wells has yet to be determined. The extent of the gas territory may be taken as equal to that of oil and salt, inheriting all the peculiarities of rich and poor areas, so common to its associates.

Professor Lesley, the State Geologist, writes: "It is certain that petroleum is not now produced in the Devonian rocks, by distillation or otherwise. What has been stored up we can get out. When the reservoirs are exhausted, there will be an end of it."

When we reflect on the measureless time during which the ancient flora and fauna of the oil and gas series have been submitted to distillation and other chemical operations, it seems impossible to conceive any of the original matter escaping these dissolving forces until the present time. It seems evident that the production of oil and gas has long since ceased. As gas is associated with salt and petroleum, it occupies the same sandstone and limestone horizons or reservoirs.

The vertical range of gas beneath the ocean level appears to be deeper than that of oil, but the great yield of gas is from the oil sands.

Mr. Carll has pointed out the fact that all deep wells, deep beneath the ocean level, have mainly proved failures for oil. The productive oil-wells are shallow, seldom penetrating over from 300 to 400 feet beneath ocean level, while gas-wells are found from 400 to 800 feet under sea level.

The large Westinghouse gas-well is about 480 feet

below ocean level; the Murraysville and Leechburg, about the same level.

Nothing more can be said of the genesis of natural gas than has been said of the genesis of petroleum. Gas is one member of the family of the oil series, just as cannel coal is one member of the family of the coal series.

The elementary constituents of this gas, from an average sample from the Leechburg well, by Professor Sadtler, are as follows:

Carbonic acid	0·35
Carbonic oxide	0·26
Illuminating hydrocarbons	0·56
Hydrogen	4·79
Marsh-gas	89·65 (CH_4)
Ethyl-hydride	4·39
	100·00

A thorough test was made last spring, by a committee appointed by the American Society of Mechanical Engineers, to ascertain the relative heating capacities of natural gas and of Pittsburg coal. It was found that one pound of coal evaporated nine pounds of water from a temperature of from 60 to 62 degrees, and one pound of gas evaporated from 20 to 31 pounds of water under similar conditions. Practically, one pound of gas is equal to two pounds of coal.

There are 23½ cubic feet of natural gas to one pound weight, or 42½ pounds in 1,000 cubic feet, the commercial unit.

This estimate, at the recent reduced rate of 20 cents per 1,000 cubic feet, makes the cost 4·7 mills a pound, or $10.52 a gross ton of natural gas.

As coal has one-half the calorific value of gas, its cost, at half gas rates, would be $5.26 a gross ton.

But the expenses of using coal in firing boilers, loading and disposing of ashes—48 cents a ton—would leave for the value of coal at boilers, $4.78 a gross ton. But the cost of coal, firing, and taking care of ashes, at some large iron works will average only $1.25 a gross ton, against $5.26 for its equivalent of natural gas.

Equating the value of the latter to the cost of coal would reduce the price of natural gas to 9⅓ cents per 1,000 cubic feet.

The following table exhibits the life of several typical gas-wells:

Locality.	Year.	Flow of gas per day. Cubic ft.	Pressure per square inch.	Remarks.
Coburn Well, Fredonia, N. Y.	1871	4,000	19 lb.	Oct., 1877—Still flowing.
Harvey, Butler Co., Pa.	1875	....	250 lb.	1876—Pressure 120 lb., dying.
Leechburg	1871	Large flow.	70 lb.	Still giving gas—1884.
Newton, Crawford Co., Pa.	1872	5,000,000	350 lb.	March, 1877—Flow small.
Burns, Butler Co., Pa.	1875	Large flow.	300 lb.	Decreased rapidly.
Delameter	1875	Large flow.	300 lb.	Decreased same year to 60 lb. pressure.
Fairview	1874	Large flow.	125 lb.	1876—22 lb. pressure.
Erie Car Works	1870	Large flow.	70 lb.	1877—17 lb. pressure.
East Sandy	1869	Large flow.	90 lb.	Three years, no gas.

Eleven wells drilled in Butler County by Spang, Chalfant & Co., are reported as follows:

No. 1, in use nine years, and is still a good well; No. 2, four years in use, diminishing, three miles distant from any other gas belt; No. 3, yield insignificant; No. 4, pressure diminished from 1½ to 0 in one week; No. 5, failed after four years' use; No. 6, in use six years, gradually failing; No. 7, failed after five years' use; No. 8, good yet, drilled in 1883; No. 9, dry hole; No. 10, small well; No. 11, a good well, gas struck recently.

These wells have been supplying the mills of Spang, Chalfant & Co., some years with varying success, being able to supply the entire plant at times, and then the wells failing; and before others could be drilled, the gas supply was insufficient, compelling the reduction of machinery or return to coal.

From the foregoing, it will be seen that the lives of gas-wells are governed by laws similar to those of oil-wells. Just how they will compare for length of life has not yet been made out; for in both cases the earliest drilled wells have afforded the largest supply, as they drew from a wide radius of undrilled territory. Afterward, the life of gas-wells, unless protected from drilling in their proximity, will be exhausted in a much shorter period than the older and more isolated wells. The past quarter of a century has unfolded the world-wide range of usefulness of petroleum. Natural gas is only in its infancy. We know little yet of these strange substances, except in their application in the industries of our time and in domestic uses.

PHOSPHATES FROM SLAG.

THE increasing adoption of the Thomas-Gilchrist process in Germany during the past few years had turned the attention of chemists in that country to the nature of the slag or refuse products of this new development of the iron manufacture. It was ascertained that among other things fully 20,000 tons of phosphoric acid were every year being thrown away with this refuse because no method had been discovered of separating it at a profit. Numerous experiments have been made during the last five years with a view to hitting upon a sufficiently cheap process, but hitherto these attempts were all unsuccessful. A few months ago, however, Professor Scheibler, of Berlin, succeeded in solving the problem. An analysis of the slag from the Thomas-Gilchrist process at one of the chief iron-works in Germany showed its constitution to be as follows: Silicic acid, 6·23 per cent.; carbonic acid, 1·70 per cent.; sulphur, 0·56 per cent.; phosphoric acid, 19·33 per cent.; iron, 9·70 per cent.; manganese, 9·50 per cent.; lime, 47·60 per cent.; and oxide alumina, 2·58 per cent. Other analyses did not materially differ from this; the quantity of phosphoric acid only varied between 15½ and 20 parts in the 100, while the silicic acid varied from 6 to 11 per cent., the proportion of lime being always nearly 50 per cent. According to the Scheibler process, only the earth phosphates and the silicates are brought into solution. The proportion of metallic oxides found in the solution is of no practical consequence, and thus the quantity of acid employed in the operation is reduced to a minimum. The phosphoric acid can be precipitated directly from the solution in the form of double basic phosphate of lime. It comes out in the shape of a powder in the finest state of division, and owing to the readiness with which in this form it is taken up by the roots of plants, these phosphates furnish at once very valuable manure without any further treatment. On the other hand, the Scheibler process leaves the metallic substances and part of the earthy bases undissolved in the slag, and since the silicic acid is nearly all taken out with the phosphates, the refuse that remains after the operation furnishes a useful material for blast furnaces and other purposes.

BRITISH AND METRIC MEASURES.

AT a recent meeting of the Institution of Civil Engineers, the paper read was on "A Comparison of British and Metric Measures for Engineering Purposes," by Mr. A. Hamilton-Smythe, B.A.

The paper was limited to comparing the advantages for engineering purposes of measures of length, surface, capacity, weight, and pecuniary value, as used in England, with decimal systems of the same classes of measures. As the arithmetical notation of all civilized nations was decimal, all decimal systems had the advantage over others of dispensing with the compound rules of arithmetic and of facilitating the use of logarithms. The metric system had the further advantage over other decimal systems of being used by 240,000,000 people, with whom 60 per cent. of the foreign trade of England was carried on, and of all its terms being correlated, and derived from one convenient, well-known standard measure of length. Some British measures had the advantage over all decimal measures of being capable of finite ternary subdivision. On account of the pre-eminent position held at present by England and the United States in the manufacture of engineering machinery and material constructed to exact British sizes, a considerable practical advantage was derived from the use of British measures in engineering works. A large amount of capital was invested in machinery constructed to manufacture British articles of exact sizes, and the engineering literature expressed in terms of this measurement was extensive and valuable. English and American engineers carried in their memories, ready for application, a great number of leading, or standard, dimensions, so that the substitution of other measures in their general practice would be inconvenient; and these measures had the further advantage of being already familiar to the working classes of England and America. Although the depreciation in value of certain machinery, due to a general change in measurements, would be very serious, still the existing machines would in any case last but comparatively few years, or become superseded by others of improved construction. The gist of English engineering literature would soon be translated into other terms of measurement, if the necessity arose. Both the meter and the yard had the advantage of being the approximate length of a human stride, and the former was about the limit to which a human being could conveniently place his hands apart when measuring with accuracy along a vertical surface. The British foot was merely a ternary subdivision of the standard yard, and in practice was often not even used as a linear unit. Carpenters, for instance, measured a plank by the number of 2 ft. rule lengths it included, and had then to complete the total length by doubling the number of units they had made use of. A plank could be measured with a meter in about one-third of the time occupied in measuring it with a 1 ft. rule. The British inch was much too large to serve as the lowest integral unit in a scale of linear measurement, and even $\frac{1}{16}$ in. was too large for minute work. The millimeter was, on the other hand, a convenient unit for ordinary minute work, and its decimal subdivisions were as suitable for microscopic work as thousandths of an inch. The English practice of taking levels for building work in feet and their decimal subdivisions, and of translating the resulting dimensions into feet, inches, and fractions of inches for the workmen, was most troublesome and productive of error. For all ordinary leveling the division of the metric leveling-staff into centimeters was sufficiently minute, as the centimeter divisions could easily be subdivided at least binarily, by ocular estimation, and metric leveling was practically more accurate for building work than levels taken with a British staff, on account of the dimensions given to the workman being in the same terms as those actually noted through the level. The 20 meter chain had the advantage over Gunter's chain in that it was capable of subdivision into the smaller linear measures, whereas Gunter's link was the lowest integral subdivision of Gunter's chain, and was too large for any work but land measuring. For engineering calculations it was desirable that the linear unit should have its multiples and sub-multiples arranged in accordance with the universal system of arithmetical notation; that it should be the basis of the units of measures of surface, capacity, and weight; and that it should be international. The meter complied much more fully than the yard with these requirements. In calculations relating to the pressure of materials upon surfaces, the intimate correlation existing in the metric system between the measures of weight and capacity was valuable, and hydraulic calculations were much simplified thereby. An engineer using the metric system had practically but one unit of measurement to deal with throughout his work, all his field measurements and the scales of all his plans being decimally expressed in terms of a meter. An engineer using British measurement had to deal with many different kinds of measures having complicated relations to each other, and also with a number of gauges, trade sizes, and local customs, which rendered comparisons of cost exceedingly difficult. Many of these would become obsolete if the metric system came into general employment. The habitual use of British measures debarred English and American engineers, to a great extent, from profiting by foreign technical literature written in terms of metric measurement. The advantages of an international language of measurement for engineering purposes were so great that they would counterbalance the advantages of any new decimal system based on units of British measurement. In so much of the work of a civil engineer's office as consisted in taking out quantities and making estimates, about one-third more work could be done within a given time with metric measures and decimal currency than could be effected with British measures and currency. Assuming that binary subdivision was more convenient for common purposes than decimal subdivision, there was nothing to prevent the use of binary subdivisions of the metric measures, as they all admitted of precise decimal equivalents. The metric scales for plans and drawings were simple, and facilitated mental comparison between the dimensions on paper and the distances in nature they represented. As regarded the salability of articles manufactured in series of sizes, there was no reason to suppose that purchasers would continue to prefer series of sizes advancing by the exact material equivalents of the sixteenths of a British inch if the fractional divisions of an inch were no longer in ordinary use as linear measures. The maximum advantage from the use of metric measures could not be obtained unless they were used in conjunction with a system of decimal currency. The reasons given by the late Sir John Herschel and Sir George Airy, Hon. MM. Inst. C.E., for preferring the decimal subdivision of the pound sterling to any other decimal arrangement of British currency, appeared unanswerable. By depreciating the nominal value of the existing bronze tokens by 4 per cent., the British currency would be completely decimalized without the introduction of new coins. For purposes of account, the penny would be 0·004 of a pound sterling, or four mills, but the name of penny could be retained. The alteration of national measures of pecuniary value could only be effected by compulsory legislation, whereas the general adoption of the metric system, being already legal, though not compulsory, might be brought about gradually through the example and influence of engineers. Judging from Continental experience, it would seem that the best prospect for reform lay in the initiative being taken by those professions most directly interested. If the Standing Orders of the Houses of Parliament allowed Parliamentary plans and estimates to be submitted in metric measurements at the option of the engineer, practical opportunities would be afforded of testing the relative advantages of metric and British measures for engineering purposes in England.

NON-ACTINIC LIGHT FOR THE DARK ROOM.

FROM the *Br. Jour. of Photography* we extract the following:

Though ruby glass is now considered indispensable in pouring emulsion and placing the sensitive plate in the dark slide, the *Archiv* thinks that yellow light may still be used with advantage to the eyesight of the operator, and without detriment to the plate, during development. Instead of the usual two sliding panes—one of ruby and one of yellow glass—the dark room belonging to the editor of the *Archiv* is at present furnished with one sliding pane of ruby glass covered by a piece of yellow fabric and a second sliding pane covered by two folds of golden yellow fabric, the latter of which is used for developing by, and is supplemented in the afternoons, when the sun strikes the window, by a fold of brown paper. As it is only occasionally necessary for the operator to hold the plate between himself and the light to examine it, a bent piece of tin is placed so as to keep the direct rays of yellow light from falling upon the developing dish, or a cover is laid over the latter. The color of two folds of golden yellow material have stood perfectly well all through the summer months, and the plates developed behind them have remained free from fog.

The editor of the *Archiv* has also used this yellow fever when traveling as a substitute for the ruby glass of a lantern, and developed during one journey over a hundred instantaneous plates by this light. The mode of using it was quite simple. He took a piece of the golden yellow material, measuring about 95 × 40 cm., and folded it twice, thus obtaining four folds of the material, which appears to have been pretty stiff. He then gave the flat fourfold stuff a bend through the middle, as if to fold it a third time, and set it up between the lighted candle and the developing dish, thus cutting off all but the yellow light from one side, while behind and above the candle the light was not interfered with. The box containing the exposed plates was placed on a chair under the table, and was only opened to take out a plate. A ferrotype plate was also set up between the yellow material and the dish. Of course, the plate being developed was not exposed to the yellow light longer than absolutely necessary to see the intensity of the image. All the plates without exception developed free from fog. The danger of breakage of the glass of the lantern when on a journey may also be avoided in a less rough and ready way by taking the framework of an ordinary dark-room lantern and replacing the glass sides by stretching four folds of yellow fabric over the frame.

With regard to the suggestions in the foregoing, Herr Carl Belz gives a formula for a yellow stain for lamp glasses for the laboratory, as these glasses in yellow are not readily obtainable:

Turmeric	½	lb.
Gamboge	2	ounces.
Sandal wood	2	"
Shellac in leaves	½	lb.
Alcohol	1½	"

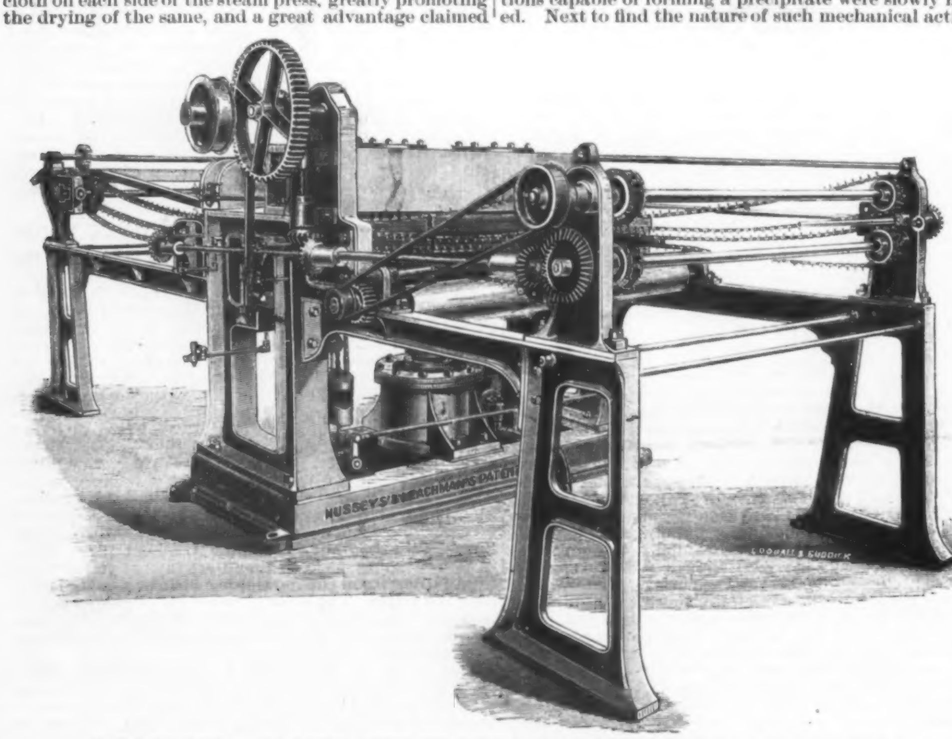
Dissolve and filter. A ground-glass lamp glass is the best to use. Warm the glass, then pour the varnish through the inner side of it, and allow it to dry without heat. It is well not to use the shade for two or three days. An inner cylinder of the lamp may remain white. If used as a shade to a gas burner, the varnish of the glass will require to be more frequently renewed than is the case with a petroleum lamp. The holder for the petroleum in petroleum lamps should be of tin, and a cardboard shade must go round outside so as to cover the holes in the burner. When gas is used, a cardboard shade measuring about 10 cm. in length must be placed under the burner. With such a light, Herr Belz says, one may manipulate plates without fear of fog, it being merely necessary not to let the light fall directly on the plate. The light is best kept off by having the lamp placed somewhat higher up than the

table at which one is working. Then place a large sheet of paste board in front of the lamp, and work in the shadow cast by it.

Besides the other reasons given by the editor of the *Archiv* for preferring yellow light to red whenever possible (principally reasons of comfort to the worker), he prefers a yellow textile fabric to glass, because the former, of a lighter shade, being only semi-transparent, really lets through quite as little actinic light as a darker shade of transparent glass.

IMPROVED CLOTH TENTERING AND PRESSING MACHINE.

THE machine illustrated is 22 ft. long, 9 ft. wide, and 7 ft. high, and one this size is capable of doing cloth from 50 in. to 70 in. wide, the chains being adjusted to the requisite width beforehand. The cloth is fed in a wet or damp state at the back of the machine, it is taken by the needles on the links of the tentering chain, and before the cloth reaches the press it is stretched out by the chains to its full width, at which width it remains for the remainder of its course. The links of the chains on each side pass close to the pattern and press plates to the front of the machine, thence similarly to the back, thence to the front, again to the back and thence again to the front, where we saw it plaited on the floor. There are thus five layers of cloth in the press, and in addition to the steam heated platen there are two steam heated press plates, and the crosshead is steam heated also. By using a press cloth or press papers between the plates, any desired finish can be obtained, as we have pointed out in our previous description. The steam after doing duty in the steam cylinder and press plates is led into a pair of heaters placed convenient to the machine, and air is blown through by a Roots or other blower. The heated air is led and allowed to play in jets between the layers of cloth on each side of the steam press, greatly promoting the drying of the same, and a great advantage claimed



IMPROVED CLOTH TENTERING AND PRESSING MACHINE.

by the inventors is that the cloth is always under inspection, it can be seen from beginning to end, and got at easily in case it tears or gets off the hooks, whereas in the ordinary tentering machine the layers of cloth are so numerous and the machine is so high that this is scarcely possible. In the arrangement we are describing, the press plates can be widened and narrowed when the machine is altered, and in order to make it work at a greater or less speed, the amount of cloth fed into the press can be varied from about 9 in. to 2 ft., the amount of time given the pressing being the same. For serges, etc., that require no cutting they can be finished in one operation with this machine, and the inventors assert that for cloths that are dyed in the piece, if passed through this machine before being dyed, more luster, less creases, and better condition are obtained by the process.

Nussey and Leachman, Leeds, England, are the makers.—*Textile Manufacturer.*

METHYLENE.

INTO a retort chloroform is added to pure zinc with a little absolute alcohol. In a short time a brisk action is set up, the zinc is freely acted upon, and a fluid is distilled over at an equal temperature of 128° Fahr. When the distillation ceases at that temperature the fluid is removed, and is again subjected to the zinc. The result is a fluid, the boiling point of which, as taken by the uniform point of distillation, is 128°, and the specific gravity of which is 1,320, compared with water at 1,000. The product has, consequently, a boiling point 14° Fahr. under chloroform, the boiling point of chloroform being 142° Fahr., and a specific gravity of 160° under chloroform, the weight of which is 1,480, taking water at 1,000 as the standard. The vapor of the fluid also burns with a blue flame, in this respect differing from the vapor of chloroform, which extinguishes flame. After the removal of the fluid from the retort in which the zinc has been, the zinc is found to have been acted upon in the freest manner, zinc chloride and oxide having resulted, the chlorine derived from the chloroform, and the oxygen from the alcohol. Whatever care may be taken, in the distillation, a little chloroform, a little alcohol, and a slight quantity of water—produced during the action—will pass over, a circumstance which has given rise to the hasty statement that the fluid called, shortly, "methylene," is an admixture of alcohol and chloroform. It is really a fluid in which the chloroform has been reduced, but from which, unfortunately, the whole of the chloroform has not been removed. If those who criticise this misfortune would discover a means by which it could be removed, I should be really grateful, the addition of the chloroform being a very distinct addition to the danger of the anæsthetic. Why this is the case I ought perhaps once more to explain. In some of these anæsthetics of the chlorine series the radical methyl, CH_3, is the cause of the anæsthesia, while the combining chlorine is the cause of the excitement and of the danger. Thus I found methyl chloride, CH_3Cl, much calmer in its action than methylene bichloride, CH_2Cl_2; and methylene calmer than chloroform, $CHCl_3$; and chloroform calmer than carbon tetrachloride, CCl_4, in which the carbon alone remains as the anæsthetic. Methylene bichloride being a liquid, I fixed upon it as more manageable than methyl chloride, and less dangerous than chloroform. As it is, it is less dangerous than chloroform, and if chloroform could be completely expunged from it, it would be very safe. But there is the crux. The small addition of alcohol and of water can in no way add to the danger, and may be disregarded. The chloroform is the diabolus.—*Asclepiad.*

CHEMICAL ACTION FROM A CAPILLARY TUBE.*

By R. S. DALE, B.A.

THE results obtained in the experiments I propose to describe were the outcome of a desire to know what, if any, mechanical action took place where two solutions capable of forming a precipitate were slowly mixed. Next to find the nature of such mechanical action, and latterly, if possible, to measure it. I have made no attempt in the latter direction, but propose describing a series of experiments which have yielded some very novel effects.

1. Solutions of lead acetate and potassium dichromate were allowed to travel in opposite directions along a thread placed in the field of a microscope. At the moment of mixing very considerable disturbance took place, accompanied with a whirling motion. This method not offering results which could be easily registered, it occurred to me to cause one solution to flow into the other through a capillary tube or siphon. The apparatus used was of the simplest possible description, consisting of a pair of cylinders connected by a capillary siphon, the effluent end of which was bent upward. One cylinder was raised slightly above the other to insure a flow. I have a photograph of the general arrangement adopted.

2. Solutions of lead acetate and potassium dichromate were allowed to mix in this manner. The latter salt was passed into the former. The capillary siphon was charged with water, and after this had passed through the heavier fluid, a series of vortex rings began to be formed at the point of the tube. Later, one attached itself to the tube, and others to this, until a tube was built up *through which* the potassium dichromate was passed, without any chemical action taking place, to the top of the lead acetate. This action continued until the system reached an equilibrium. Fearing that I could not show the experiments before the Society, I photographed some of them, and they show exceedingly well the curious growths of lead chromate which were thus produced. With these two substances to obtain a single tube was most difficult, and only a series could be obtained with anything like certainty.

An experiment was made, reversing the fluids. The same results were obtained, though the growth was less stable, as the potassium dichromate being of much smaller specific gravity, no support was given to the lead chromate formed, and thus the growth continually fell off the point of the siphon.

3. A cold saturated solution of sodium sulphate was passed into a saturated solution of barium chloride. A perfectly straight tube was obtained, which formed with great rapidity, and was very stable. This result was most unlooked for, taking into consideration the great density of barium sulphate.

4. A solution of ammonium oxalate was passed into a solution of calcium chloride. These particular solutions were chosen because the amorphous calcium oxalate first produced on mixing these solutions rapidly becomes crystalline, and the effect could not be surmised on mixing with a capillary tube. The usual phenomena took place until the tube reached the height of about one inch, when the amorphous calcium oxalate suddenly changed to the crystalline variety, and apparently stopped the action, as no further upward growth took place. On careful examination, however, of the point of the growth, a fluid was noticed to emerge which had no action on the surrounding calcium chloride, showing that chemical action was still going on. Now, the upward growth having ceased, it was inevitable that the tube should become wider, and this is what really took place. On another experiment I obtained a nearly spherical body, about half an inch in diameter.

5. Action of ammonia on ferrous sulphate.—A very thick tube of ferrous oxide was formed, which I am able to show you, as it is by no means fragile. It has of course been since, out of the fluid, partially converted into ferrous oxide.

6. Sodium carbonate on copper sulphate.—In this case a crystalline copper carbonate was obtained of two shades, one a bright blue, resembling azurite (if it be not actually that substance), and another a bright green, resembling malachite. I am able to show this tube.

7. Ammonium sulphide on copper sulphate.—An action closely resembling, in many particulars, the action of ammonia on ferrous sulphate.

8. Sodium carbonate on calcium chloride.—The commencement of the action was marked by the formation of a perfectly transparent and highly refractive sheath of calcium carbonate, which did not show any signs of crystallization until about half an inch in length. On examination after the lapse of about twelve hours, a crystalline tube of calcium carbonate had made its way to the top of the containing cylinder. This tube was composed of minute but well defined crystals. I found it impossible to retain it in its perfect shape for inspection here.

9. Sodium carbonate on barium chloride.—A very similar action to that mentioned in experiment seven, but at no time was a transparent substance noted, the growth being quite opaque and not palpably crystalline.

10. Hydrochloric acid on sodium silicate.—Here a well marked action took place, and a tube of silica was produced, a portion of which I am able to show.

11. Knowing the silica produced by the action of ammonium chloride on sodium silicate was much denser than that obtained in the previous experiment, I caused these substances to act on each other, and succeeded in obtaining a very long tube of silica of considerable thickness. I am able to show this also.

12. Ferricyanide of potassium on ferrous sulphate.—Notwithstanding the extreme lightness of the blue precipitate produced by these solutions, a perfect tube was obtained, which reached the surface of the ferrous sulphate.

Many experiments on the above lines will readily suggest themselves, but I think I have described sufficient to call attention to this, to me, novel method of experiment, and I must leave it to some future occasion to describe such others as may show any peculiarities worth noting. I purposely refrain from making any theoretical deductions, with the one exception that it is pretty certain that these phenomena are inseparably connected with vortex action, the tubes being undoubtedly built up of a series of vortex rings.

* Lately read before the Manchester Literary and Philosophical Society.

PROPERTIES AND CONSTITUTION OF SEA-WATER.

By M. ANTOINE DE SAPORTA.

IT has been said that, without the sea, civilization could not have been developed, and the world would have continued barbarous. That element, from the primitive times of mankind, has brought together the peoples of the most distant countries, and inspired the ancients with the idea of the Infinite. Homer believed in a river Oceanus; the Hindoo mythologians, in a liquid expanse, boundless as space. The fishermen who set their rude nets in the creeks of the Cyclades were, perhaps, the first naturalists, and the Phœnician sailors may have been the first marine engineers. In our own time, all the sciences find in the ocean either a limitless field of exploration or an enemy to be conquered. Zoologists, closeted in their laboratories, endeavor to determine the beings which the dredge has brought up from frightful depths, while hydrographers and constructors study the currents, raise jetties, and excavate ports. The public visit the aquariums, admire the dikes and excavations, and applaud what they see, but do not see all. Our purpose is to explain the researches of the modest investigators who have occupied themselves with the chemical constitution and physical properties of sea-water.

Sea-water, it is well known, when it is not muddy, is one of the clearest of all natural waters. When we walk along the shore at low tide, it is often difficult, unless we are careful, to keep from stepping into the occasional pools on the rocks, the water in the little hollows being so transparent as to be invisible. The question of the color of this water deserves serious examinations, and labors on the subject are not wanting. The most notable ones are those of Father Secchi, of Professor Tyndall, and the more recent researches of M. W. Spring and M. Soret.

Father Secchi made his experiments in 1865, on board a pontifical corvette. A number of disks, formed by stretching variously colored cloths over iron hoops, the largest twelve feet in diameter, were let down at a time when the conditions of the weather were most favorable for transparency. The largest disk, which was painted white, became invisible at the depth of about forty-two meters, while the smaller disks and a Delft plate, distorted by refraction, went out of sight at smaller depths. The disappearance seemed to depend upon the confusion

of the image, which was broken up in every direction. The largest disk, the considerable surface of which offered more resistance to the distortion, finally ceased to be perceived, because its color, turning in succession to light green, blue, and dark blue, became at last as dark as the surrounding medium. Disks painted yellow or red were lost to sight still more quickly, or under not more than twenty meters of water. Repetitions of similar experiments gave co-ordinate results; and it may be stated, as a general rule of average, that the practical limit of submarine vision, under favorable circumstances, is at twenty-five meters under the surface.

It was found, by spectroscopic examinations of the light reflected from the differently colored disks, that the yellow was enfeebled and extinguished first, and next the red, under the increasing thickness of the overlying water. By the gradual disappearance of these two colors, a white object is made to pass through green to blue—the tint which all such objects finally assume when sunk under salt water. Each of the three simple colors—yellow, red, and blue or violet—has its distinct part among the solar rays. Yellow is luminous, red is calorific, and violet-blue provokes chemical reactions. Water, in a very thick mass, is neither transparent nor diathermanous; but, being penetrable to the blue, indigo, and violet rays, it is diactinic. These radiations, too, will, of course, gradually lose their energy, and become extinguished at last in a very deep stratum of liquid; but the limit is extremely remote.

According to the theory propounded by Professor Tyndall, the sea-waves present three principal hues—blue, green, and yellow. The indigo-blue waters are the purest, while the yellow ones contain muddy matters in suspension, and the green ones are slightly charged with such substances. The solid particles held in the water constitute a multitude of infinitely little mirrors, from the outside of which is reflected the light that penetrates the mass of the liquid. The rays which are sent out, after having traversed only a thin stratum of water, preserve their yellow parts. If the reflections are attenuated, the water appears green; and if, on account of the absence of solid matter, they do not exist at all, the sea is of a deep blue. In an indigo sea the crests of the waves will appear green on account of their lack of thickness. The same rules are applicable to fresh water; for the salt is almost without effect on the color of sea-water—not quite without effect, for according to M. Spring, the clayey particles which make the waves yellow are precipitated with a rapidity proportioned to the salinity of the sea. These general laws are liable to be disturbed by numerous accidental circumstances or local causes. The presence of sea-weed or of microscopic animalcules may have great influence on the color of the water. In tolerably shallow basins, the color of the botton has its effect.

Several seas or gulfs have been given names alluding to their colors. Some of these terms can be explained without difficulty, but others are not so easy to comprehend. The White Sea is so called on account of its ice, the Black Sea from its storms, and the Yellow Sea from the muddy waters poured into it by the Chinese rivers. The waves of the Vermilion Sea, near California, are colored by the Rio Colorado, which itself has a characteristic name. The water that washes the European coasts has no perceptible odor; or, if in single cases it may be odorous, the smell is due to mud or to decomposing organic matters contained in it. Drinking-water which is stored for some time may also acquire a smell which it had not at first, through the decay of the impurities in it. The cork of bottles containing salt-water is sometimes eaten by sulphureted hydrogen formed in the water.

Sea-water owes its characteristic taste to the chloride of sodium held in solution, and to the bitter salts of magnesia which it contains. Sometimes organic remains or weak proportions of fatty matters become mixed with the superficial strata, so as to make them more nauseous than the same water drawn from greater depths. The pleasant taste of the water inclosed in oyster-shells is due to the savory animal juices that are dissolved in it. Mussels, which live and are fished near the shore, sometimes absorb impurities from the drift-matter around them, from which they develop the poisonous alkaloids called *ptomaines;* hence they are unhealthy at some seasons.

By a scientific prejudice that ruled for a considerable time, the bitter taste of sea-water was believed to be caused by traces of bitumen. The chemists who made analyses consoled themselves for not finding a sign of that substance, the existence of which they suspected, by supposing the proportion was too slight to be appreciable. Count Marsigli, who in the reign of Louis XIV. tried to make sea-water artificially, took great pains to mix bitumen with the salts he put in solution, in order to make the reproduction perfect. The partisans of the theory cited the Dead Sea, which was near asphalt-beds, and the waters of which were insupportably bitter. But Macquer, assisted by Lavoisier, a hundred years ago, carefully distilled specimens of this water, and found in it no more bitumen than had been found in Mediterranean water—which was none at all. He attributed the bitter taste of this water to the presence of salts of magnesia.

It is not to-day that investigators have sought to make sea-water potable by removing its nauseous taste. The problem was solved long ago, and, as often happens, the usefulness of the invention once so greatly desired has been much depreciated. When fresh water for the provisioning of vessels was stored in wooden casks, it was liable to spoil in a short time. Now it is carried in large iron tanks, in which, instead of spoiling, it is improved by acquiring a ferruginous quality. The ancients did not venture far from the shores, and were contented with a simple coasting-trade; nevertheless, this question interested them, and Pliny describes two means of freshening the water of the Mediterranean, one of which is absurd and the other impracticable: One was to plunge into the sea hollow balls of wax, which, the author affirms, would be filled with pure water; and the other was to expose fleecy sheep-skins on the deck of the vessel, to collect the morning dews.

Whoever examines the series of memoirs published during the seventeenth and eighteenth centuries, on the subject of freshening sea-water by distillation, must be struck by the divergence of opinions and the want of concordance in the results, some declaring that distilled water is pure, healthy, and tasteless, others that it is unhealthy, and almost as detestable as before the operation. The differences between them are easily explained. Marine salt is not the only substance dissolved in the water, but is accompanied by several other bodies, the principal of which is chloride of magnesium. This salt when dry resists the action of the most violent heat without changing; but in boiling water undergoes a double decomposition, in which the chlorine leaves the magnesium to unite with the hydrogen of the water, while the oxygen thereof unites with the magnesium. There is thereby produced magnesia, which remains in the vessel, and hydrochloric acid, which is distilled over. Now, distilled water is made impotable and unhealthy by any traces of that acid. The difficulty may be obviated by previously removing such salts as can be made to settle, or by adding fresh sea-water. Water boils at a temperature several degrees higher than usual when it is charged with salts. If it is sufficiently diluted, it will not disengage hydrochloric acid. Or the acid may be absorbed by substances added to the water for that purpose, and which will not give it up again. Such substances are lime, chalk, potash, soda, and calcined bones, all common and cheap.

The problem of freshening sea-water was formerly regarded as so important that other means of solving it besides that of evaporation were advanced. Even the great Leibnitz lent his name to a proposition which was judged singular, if nothing worse, by his contemporaries. It was to freshen water by forcing it through a filter filled with litharge; but he never tried the experiment. It was believed, on the authority of Pliny, that if an empty bottle, hermetically sealed, were sent down deep into the ocean, it would come back full of pure water. But it was proved that the bottles would either be broken or come back empty. Other naturalists tried filters of earth or sand. But when Réaumur and the Abbé Nollet constructed a gigantic filter of glass tubes filled with sand, a thousand toises long, they found that the water came out of it as salt as it went in. Lister, in 1684, placed sea-weeds with their stems in water, after the fashion of a bunch of flowers, in an alembic which he did not heat, believing that the fresh water would ooze out in drops from the upper part of the plants; but he had to acknowledge that no great result came from his curious process. Samuel Reyer made a discovery of some practical value—that melted sea-ice furnished a potable water. Notwithstanding numerous distilling apparatus were devised by various inventors, ships continued to be furnished until very recently with water stored in casks. The inventions had little practical value, and the management of alembics when the sea was rough was a matter of considerable difficulty.

The sea is in reality an immense and inexhaustible mineral spring. Probably, if it only contained pure water, a fountain as rich in mineral matters as the ocean actually is would attract crowds of drinkers, and would be recommended for internal use in all imaginable diseases. But sea-water is abundant and common, and has never been much used internally. On the other hand, the therapeutic employment of sea-baths might be made the occasion of long dissertations.

It is generally known that a strong dose of sea-water acts as an emetic; in weaker proportions it is purgative and diuretic. Dioscorides advised diluting it with honey, which might, perhaps, produce an efficacious medicine, but certainly not a savory one. At the beginning of this century it was diluted with wine, but such a mixture could hardly be better than the other one. It was prescribed in Spain against the yellow fever, and in England against worms; in the former case, as an emetic; in the second case, milk was added to it so that the child could drink it without aversion. Sea-baths have been tried as remedies for hydrophobia and insanity, but, it is needless to say, without effect.

Marine water contains a little iodine; it is therefore a resolvent, and adapted to external application for tumors and ulcers, although more energetic and sure remedies are generally employed. Even before iodine was discovered, more than a hundred years ago, Russel had remarked the efficacy of calcined sponges and corals, and of the ashes of sea-weed, substances richer in iodine than sea-water itself.

A general study of the physical properties of sea-water would not be complete if it was limited to that at the surface. It is necessary to otain specimens drawn from different depths, especially as the density and temperature vary with the depth. Various apparatus have been contrived for bringing to the surface a quantity of water drawn from any desired level. A long-known means, and at the same time a simple and practicable one, is to let down by a rope an empty bottle corked. The increasing pressure upon the bottle becomes strong enough at certain depths to push the cork in and fill the bottle. The rope is then drawn up, and the liquid inside the bottle coming in contact with less dense waters, pushes the cork back into the neck of the bottle and closes it. Thus the water from the deep keeps itself free from mixture with that of the superficial levels. Other more perfect apparatus have been invented, all dependent upon the automatic closing of the vessels.

Salt water is denser than fresh, because of the gravity of the dissolved salts. But wherever large rivers enter the sea, as in the Black Sea and the Baltic, and in cold climates where evaporation is slow, the superficial water is light and of inferior salinity. The water of the Norwegian fiords is brackish, and that of the Gulf of Bothnia, at the upper end of the Baltic, is, in an extremity, potable. The glaciers of Greenland and Spitzbergen pour out in the summer torrents of fresh water which tend to freshen the spaces around their mouths. There is likewise a deficiency of salt in the waters of the White Sea, the Kara Sea, and the Siberian Ocean. Inversely, the Mediterranean, which does not receive, in proportion to its extent, so many nor so large rivers, and is exposed to the ardors of a burning sun, would become indefinitely concentrated by evaporation, were it not that an under-current of less dense water was sent into it by the Atlantic Ocean through the Strait of Gibraltar. Copious rains may play some part in the matter, and that is another reason why Mediterranean waters should preserve their density. Evaporation is very great in the tropics, but the liquid concentrated by it is also expanded by the heat, so that the two effects partly balance one another.

In all the old books on the physics of the globe, and even in some recent ones, no difference was made as to the law of maximum density between salt water and fresh. The latter begins to expand by heat at 4° C. (39° Fahr.), but, between the freezing-point and that temperature, it contracts when it is warmed, so that at 39° Fahr. it is denser than at any other temperature. In temperate countries, the water of the bottom of deep lakes remains at nearly 39° Fahr. by means of its weight, which prevents it from rising to the surface and mixing with either the colder or the warmer parts, and also because water conducts heat very badly.

The phenomena are different in the case of sea-water, and also complicated in other ways. The point of maximum density descends as the weight of the salt water and its richness in dissolved matter increase. The Swedish chemist and hydrographer, Ekman, after long series of experiments relative to this question, has found that this critical temperature may fall to —4° C. (25° Fahr.) in Atlantic water. The properties of a brackish fluid, such as would be drawn from a fiord, would naturally be intermediate between those of a pure and those of a very salt water. Hence the depths of the ocean cannot be at 39° Fahr., as some authors still maintain. A slight excess of salt in solution will weight a stratum of water of mean temperature, whereby a cold zone may be superposed upon another zone which is warmer, but more saline. The interior of the ocean, as well as its surface, is plowed by numerous currents, some warm, some cold, which meet, mix, and separate again, so that it is very hard to find out by reasoning what experiment alone can teach. A similar variety is shown in the density of water brought up by soundings. The complication is magnified when we reflect that water is not absolutely incompressible, that each thickness of ten meters exercises a vertical pressure nearly equal to an atmosphere, the action of which added to that of the superior parts weighs upon the inferior liquid, so that at about 4,000 meters the pressure is 400 atmospheres. Water must be extremely dense when it is compressed with so much force, and the influence of salinity and temperature must become very small in these unfathomable abysses. The question of submarine temperatures has given rise to many controversies. Some, with Perron, suppose that the great depths are always cold, like the tops of the highest mountains. On the other extreme, the author of "Epochs of Nature" attributed to the oceanic depths a high temperature on account of their nearness to the central fire. Denis de Montfort and Humboldt are of the opinion that below the superficial parts there prevails a constant temperature, peculiar to each station, and corresponding with the mean annual temperature of the place. This view is correct for regions where the depth is not very great, and in certain bodies of water.

The sea, on account of its great specific heat and its feeble conducting power, plays the part of a moderator of temperature something like that of the fly-wheel of an engine as a moderator of force. In winter it is warmer, in summer it is cooler, than the ambient air, and the difference is emphasized the farther we get away from the shore.

In "The Clouds" of Aristophanes, Strepsiades refuses to pay his creditors who hold that the level of the sea is fixed, believing that, as it receives all the water, it must continue to rise indefinitely. The phenomena of evaporation were not very well understood at that time. Even in the seventeenth century, Father Fournier talked of subterranean fissures or crevasses in which the waters of the Baltic and the Mediterranean, incessantly swelled by the rivers and by the currents of the Sund and of the Strait of Gibraltar, constantly lost themselves. During the last three years, the question of the evaporation of sea-water has been much discussed between the partisans of the Saharan sea and their adversaries. The great point was to ascertain whether the proposed sea would not in the end become an enormous marsh. The sub-commission of the French Academy of Sciences was of the opinion that, other things being equal, salt water would evaporate less rapidly than fresh. Experiments by M. Dieulefait, on the other hand, indicated that a nearly equal loss would occur in the case of salt water and of fresh.

Fresh water freezes at 32° Fahr., but a liquid charged with salt congeals at lower temperatures; the rule is about the same as for the maximum of density, except that water slightly salt undergoes its contraction before being converted into ice, while normal sea-water acquires its minimum volume only in a state of surfusion, or when maintained artificially in a fluid state in capillary tubes. In this condition, a number of substances, water among them, are susceptible of being cooled considerably below their point of congelation and still remaining liquid. In the Baltic and White seas, the waters of which for some depth are but weakly charged with salt, ice forms on the surface when the surrounding temperature has become low enough, while immediately below are strata more dense and relatively warmer. But suppose that below a certain depth of a brackish and warm liquid there is a cold salt current; the latter would produce such a refrigeration in the mixed intermediate strata that a mass of ice would be formed in the interior of the sea at the expense of the less saline zone. The block when formed would rise to the surface by virtue of its specific levity. This is what happens at the mouths of the great Siberian rivers. The Lena, in particular, pours out an enormous mass of warm water which overwhelms the salt waves from the polar regions. Even in the most favorable seasons, the navigator sails in the midst of floating ice-cakes that constitute a constant source of danger, while the thermometer dipped in the sea will indicate a temperature above the freezing-point. The depth of the warm stratum varies with the year, the place, and the prevailing winds; and hence we account for some explorers declaring impracticable tracts which others have easily sailed over. The northeast passage along the Siberian coast can never become a regular commercial route, unless, by repeated soundings accompanied by attentive studies, we can finally discover regular and periodical laws for the phenomena under consideration.

The Swedish physicist, Edlund, having inquired of the Scandinavian fishermen, was assured that they had sometimes, though rarely, seen the sea near the fiords of their country "vomit fragments of ice." The following is a textual reproduction of the story of one of the sailors concerning this curious and still little-known fact: "Not every year, but times enough, out on the open sea, I have seen ice come rapidly up to the surface. If the weather is calm, we can perceive, as far out as we can see, small cakes in the shape of a plate coming from the bottom rise to the surface. The edge

is in the air, but, when the upper part of the plate gets above the level of the water, the plate turns over and lies flat upon the liquid. It is a dangerous business, for a boat may thus in a few minutes be surrounded by immense masses of new ice." *

Aside from this anomaly, the formation of isolated blocks of ice in the open sea is very rare. Water of ordinary salinity becomes denser as it cools, for it freezes at about 28° Fahr., and, as we have explained, attains its maximum density at about 35° only if we keep it artificially in the liquid condition. Water that has lost its caloric in contact with the atmosphere soon sinks; sometimes, as Scoresby attests, ice which is formed at medium depth rises to the surface, while sounding thermometers indicate temperatures near or even below the point of congelation at the bottom. Otto Petterssen is of the opinion that, if water submitted to a cold of a few degrees below its freezing point does not solidify, it is because immobility favors surfusion, or rather, what is very possible, because we do not know all the laws of nature.

Mr. Pettersen has succeeded by a series of experiments in explaining a variety of phenomena which manifest themselves in the boreal seas, and which Arctic explorers have long been acquainted with, without understanding the reason of them. Sea-water after its passage to the solid state has not the same chemical composition as before; but besides this change, which we shall speak of again, it has another interesting peculiarity. If the temperature is very low, the ice of the ocean, like nearly all known bodies, contracts by cold; but at a few degrees below the freezing-point, and before melting, it diminishes in volume when heated, and dilates on cooling. Between 14° Fahr. and —4°, according to the age and source of the block, there is produced a minimum of density, the mass acquiring its maximum volume, that is, the behavior of the solid is the inverse of that of river-water.

While it contracts by heating at about 18° or 23° Fahr., the ice of salt water loses some of the properties which it possesses at lower temperature, and which are common to it with ordinary ice. It has no longer the vitreous aspect, the fragility, and the homogeneity of solid ice, but becomes softer, more plastic, and less transparent; its fracture is less distinct, and cracks and holes multiply in it. And, when brackish water congeals, it loses its disagreeable taste, but its bad looks and want of limpidity deprive it of commercial value.

Sea-water is a very complex saline solution; chemical analysis discovers in it halogen radicals, simple, as chlorine and bromine, or compound, as sulphuric acid and the four basic principles, soda, magnesia, lime, and potash. Chlorine is by far the most abundant principle, and should be credited with more than half the weight of the saline matter. Open any book on chemistry or the physics of the globe, and you will find that sea-water contains, by the liter, so much chloride of sodium, so much sulphate of magnesia, so much chloride of magnesium, etc. These affirmations are wholly hypothetical, for our acquaintance with chemistry is not sufficient to permit such conclusions. Analysis shows that there are in a liter of sea-water so much chlorine, so much sulphuric acid, and so much magnesia, but does not reveal to us how the radicals are united, for the combinations we get in analysis are not probably precisely the ones that existed in the water. We might say that the numerous simple bodies entering into the composition of sea-water are all the time contracting new and incessantly variable alliances, according to the temperature or the concentration of the liquid. It is by intelligently utilizing these laws that they succeed at the salt works in forcing the mother-waters to deposit at one time cooking-salt, at another time some other combination useful in industry, or which it is desirable to get rid of.

In evaporating to dryness a known quantity of sea-water, under certain precautions, we obtain a residue which, well dried and weighed, furnishes the weight of the total quantity of salts originally dissolved. It is then easy, by a simple calculation, to estimate the proportion of solid substances contained in a liter. Salt water is denser than fresh water of the same volume and temperature, and this excess of density is evidently proportional to its richness in saline matters. This can be obtained by multiplying the excess of density by 1·32. We may thus replace the chemical operation by a determination of density, an easier experiment, and one that can be made on board ships.

The different oceanic regions are not equally rich in salts. What we have said respecting variations of specific weight shows this very clearly. But if we always draw the water from a sufficient depth, the variations become much less, as Forchhammer has proved. The figures in his tables oscillate between thirty-four and thirty-five grammes per liter. The relative proportion of the different elements is still more invariable, and we can establish a few slight differences only by taking the means of a large number of estimations. This fixity of relation might have been foreseen, because evaporation concentrates, without taking away an atom of salt, while fresh waters dilute without furnishing any. It follows, then, that the composition of a specimen of sea-water can be estimated with a fair degree of accuracy by ascertaining the proportion of one of its constituents, the chlorine, for instance, and that element is much used as a standard. The amount of chlorine in a liter of liquid collected along the shore diminishes obviously when the ship is approaching ice, or if it is cruising near the mouth of a great river.

When concentrated by any means, sea-water deposits, first, carbonate of lime, next gypsum, or sulphate of lime, and then salt; and, lastly, the salts of magnesia and the bromides. The phenomena are not quite so simple in practice, and the deposits of salt marshes are rarely composed of a single substance; but we have only intended to indicate the general course of the operation. The salt of commerce is rich in magnesia, or chloride of magnesium, in proportion to the strength of the concentration. Some have even sought to ascribe the enormous deposits of gypsum found in certain regions to ancient seas, which, in drying up, deposited that substance among the first.

Potash and the bromides, substances that are relatively little abundant, accumulate in the mother-waters until they become so condensed as to make the industrial working out of them remunerative. Bromine is less abundant in the Mediterranean than in the waters of the Dead Sea, which may some day become a source of production. Eighteen centuries ago the Romans, according to Pliny, brought to Italy at great expense the water of the Asphaltine Lake, the curative properties of which were held in high esteem. The excess of bromine in this water, however, corresponds exactly with its greater total saltness, so that, except for a few qualifications to which we shall refer again, the relative composition of the dry residue of the Dead Sea is the same as that from the ocean. In other words, any marine water evaporated to the same degree of density as that of the Dead Sea would be as deleterious to living beings.

Marine ice was formerly regarded as formed of solidified pure water retaining by mechanical adhesion traces of the saline liquid. These traces could be expelled by energetic pressure, when acids and bases would be found in the residue of desiccation in invariable proportions as in the sea. The question of chemical composition of the ice of the Arctic Ocean is complicated in other ways, but it gains in interest what it loses in simplicity. When salt water is cooled artificially, a small part escapes solidification. The uncongealed residue is insupportably bitter to the taste, and analysis shows that nearly all the magnesia is concentrated in it. The solid block, if it is homogeneous and is not full of holes, and if previously drained, may furnish a passable drink. The natural ices of the Northern Sea are frequently moistened with a kind of brine, which sometimes embodies crystals of special character, easy to distinguish from the ice around them. According to Otto Pettersen, the relative proportions of chlorine and magnesia are much stronger in these exudations than in the water at the expense of which the ice is formed. The liquid cannot then have been mechanically absorbed. On the other hand, there is a deficiency of sulphates; and the conclusion that sea water ice retains the sulphates more abundantly is confirmed by analysis. With congelation, a sorting of matters takes place, most of the sulphuric acid passes into the part that solidifies, while magnesia and chlorine prevail in the part that remains liquid. Under the influence of variations of temperature, all the chlorides in the block will gradually disappear; some go into the sea and are dissolved; while the rest appear on the surface and form hydrated crystals, or a kind of "salt snow." The sulphates thus prevail exclusively in old ices, which, according to Mr. Pettersen, constitute mixtures of solidified water and a peculiar chemical compound, the criohydrate of sulphate of soda, a body which, containing five parts of soda to ninety-five of water, is decomposed at a little below the ordinary freezing point.

By these phenomena of selection, ice, under atmospheric vicissitudes, approaches a limit when its composition would be fixed, without reaching it in reality. Usually, the expulsion of chlorides is not complete, and sudden changes of temperature may liquefy it at once. The Swedish observer compares the ice of salt water with a kind of granite, each constituent of which should take its turn at decomposing under special circumstances. The warm waters farthest from the pole would bear only the stable constituents brought down by the Arctic current, so that, to continue our comparison, the river, which has gradually eaten away the granite block, finally transports the last remains of the block in the form of sands and clays, which are destined to accumulate in the sedimentary deposits.

Over and above the substances that exist in considerable proportions, many rarer elements are found in the waters of the ocean; minerals, gases, and organic remains, difficult perhaps to recognize, sometimes impossible to estimate, but which nevertheless play an important part. The phenomena of accumulation which we have considered are absolutely insignificant in comparison with the absorbing power of some of the algæ. In them Courtois discovered iodine in 1812, and Malagutti, after laborious researches, detected copper, lead, silver, and iron, metals which he afterward found in sea-water itself.

The quantity of iodine contained is so little appreciable that many doctors have denied the therapeutic virtues which others have attributed to this water. Nevertheless, absorbed and condensed by marine plants, it becomes abundant enough to be extracted with profit. It likewise accumulates in animal organisms; and cod liver oil owes its beneficent properties to it.

The silver was absurdly attributed by Proust to the treasures of shipwrecked vessels. But the quantity, though infinitesimal in a measured quantity of water, is in the aggregate immense. Malagutti more rationally refers its origin to the solution of the lead ores, very abundant all over the globe, with which sulphurets of silver and copper are combined. By the action of salt, the sulphurets are converted into chlorides. As to iron, it would be strange if so universal a substance were not found in the sea; and the same may be said of phosphoric acid.

The researches of M. Dieulefait into the presence of lithium in sea-water have shown that the Dead Sea is an independent body of water, and not an abandoned lagoon of the Red Sea. By chemical and spectral analysis, it contains neither iodine nor silver, nor lithine, while all those substances are found in the Arabian Gulf, a body whose waters differ from those of the oceans only by their greater density, consequent on the strong evaporation to which they are subjected.

The determination of the air dissolved in the ocean is attended with many difficulties. We can only indicate a few prominent principles.

This air has not the same composition as the air we breathe, although it differs but little in that respect from the air held in springs and rivers. Oxygen, which forms only a fifth of the atmospheric air, being more soluble in water than nitrogen, constitutes about one-third of the air which is expelled from water by boiling.

The volume of gas absorbable by water diminishes as the temperature rises. Cold water is richer in air than warm. Moreover, the law of decrease being regular for nitrogen, while it is less simple for oxygen, the relative proportions of the two elements are variable in waters of different temperatures.

According to Mr. Tornoe, there is a little more oxygen at the surface than theory calls for, while in the zones where animal life is largely developed there is a slight deficiency.

The presence of sunlight, or the cutting of it off by clouds, has no important effect; and the same may be said of the enormous pressures to which deep-sea waters are subjected. But little carbonic acid occurs dissolved in a free state, although that gas is very abundant in combination. Mr. Tornoe, who has given this subject careful attention, thinks the older chemists collected carbonic acid products of the decomposition of carbonates or bicarbonates at the boiling point. He finds an alkaline reaction in sea-water, which he attributes to a small quantity of free salts of soda.

Mr. Hamberg, a Swedish chemist, who has recently studied the waters of the Greenland seas, agrees with Mr. Schloesing that marine water contains neutral carbonates, bicarbonates, and slight traces of free carbonic acid, and that temperature and atmospheric pressure have a complex influence on both the uncombined gas and that which is united to bases.—*Translated for the Popular Science Monthly from the Revue des Deux Mondes.*

* We owe these details to the kindness of M. Otto Pettersen, who has furnished us with many interesting facts, the fruits of his personal observations.

THE SOURCES OF ELECTRICITY.

Professor Tyndall lately delivered the second of his course of Christmas lectures at the Royal Institution "On the Sources of Electricity."

Professor Tyndall said that when he rubbed a brass tube with a catskin electricity is produced, which escapes at once through the metal and his body to the earth; but let the tube be insulated by a non-conductor, that escape is prevented. In old times substances were divided into electrics and non-electrics, but in the one case the electricity was held on the surface of the body, and in the other it escaped to the earth. In the action of an excited glass tube upon a conductor, the positive electricity of the glass drives away the positive electricity of the brass to the earth. He indicated this passage by causing it to diverge the gold leaves of the electroscope, which divergence he next neutralized by the negative electricity from excited gutta-percha, whereupon the leaves fell together again. He then suspended a poker by silken threads, touched it with an excited glass rod, and then obtained a spark from the poker, by which he lit the gas. He placed himself upon an insulated stool, passed an India-rubber comb ten times through the dry hair of his head, and between each application of the comb to his hair his assistant passed it momentarily through the flame of a spirit lamp to discharge the electricity of the comb; his body then contained enough electricity to enable his hand to attract one end of a large lath balanced on a pivot in such a way that it could turn freely in horizontal directions. This experiment, he said, had been exhibited for the first time in that theater several years ago, and by himself. Electricity, he added, diffuses itself over the surfaces of bodies, and does not always do so equally; for instance, in a cone with rounded edges more electricity is obtained from the point than from the center. He proved this by means of a little carrier with an insulated handle; this carrier gave a greater divergence of the electroscope leaves when he took the electricity from the point of the cone than it did when he took it from the center. In like manner he proved that electricity in a metallic disk accumulated more at the edges than at the center.

The speaker next dealt with the properties of hollow conductors, using in the first instance a silver teapot. He charged with electricity a brass ball held by a silken thread, lowered the ball into the open teapot, then showed that the teapot contained no electricity inside, but plenty outside, especially at the end of the spout. If himself or a little boy could be put inside that teapot, he explained, no electricity would be found there. Faraday once made a little house of laths at the Royal Institution; it was 12 ft. square, and covered with tinfoil; while he was inside that house not a trace of electricity could he find there with the most delicate instruments, while the house was in communication with a most powerful battery, and giving strong sparks outside.

Professor Tyndall next spoke of the influence of points, saying that one experimentalist had determined the sharpness of thorns by their action upon electricity. He electrified a great insulated paper tassel, thereby causing its long strips of paper to diverge, and the distant as well as the near approach of a needle point made the strips fall together again; this, he said, explains the principle of the lightning conductor. He exhibited a lightning conductor with several points tipped with platinum; from his little experience he was inclined to think that one point to a lightning conductor was as good as many; still it might be right to have several.

The conductors should have a good earth connection at the bottom, and not be put but 2 in. into it, as a builder did on one occasion. The Board of Trade has a lighthouse on the north coast of Ireland, in which the bottom of the lightning conductor was once led into the solid rock at the base; he wrote to the authorities, after an accident to the structure from lightning, saying that they invited the lightning to strike the lighthouse, and that the bottom of the copper rod should have been connected with the sea. The best discharger of electricity is a flame; it is more efficient than metal points. A wind flows from electrified metal points, the air being made self-repulsive. He then put some water with the chill off in a flat glass cell, and dusted a little lycopodium on the surface of the liquid; the wind from an electrified point made the particles self-repulsive, and their eddies were exhibited in magnified form upon the screen by the aid of the electric lantern. The electric mill, in which vanes are driven round by the wind from an electrified point, was next exhibited.

The electrophorus, he said, was discovered by Volta, to whom a statue has been erected in the market-place at Como, because of the great honor in which that early electrician is held, not alone in Italy, but all over the world. He then brushed the rosin and wax plate of the electrophorus with the catskin; brought the conducting disk down upon the plate, and showed how a spark was obtained from the latter. A sheet of vulcanized India-rubber, he proved, will do as the plate of an electrophorus; a disk of tin, with a sealing-wax handle, will do for its conductor; so also will a half-crown attached to a stick of sealing-wax. By the latter means he obtained enough electricity to enable the half-crown to attract the end of a freely balanced lath. He next exhibited the electrical machine of Mr. Whimshurst, who he said was connected with the Board of Trade; he was a man who had not tried to make money out

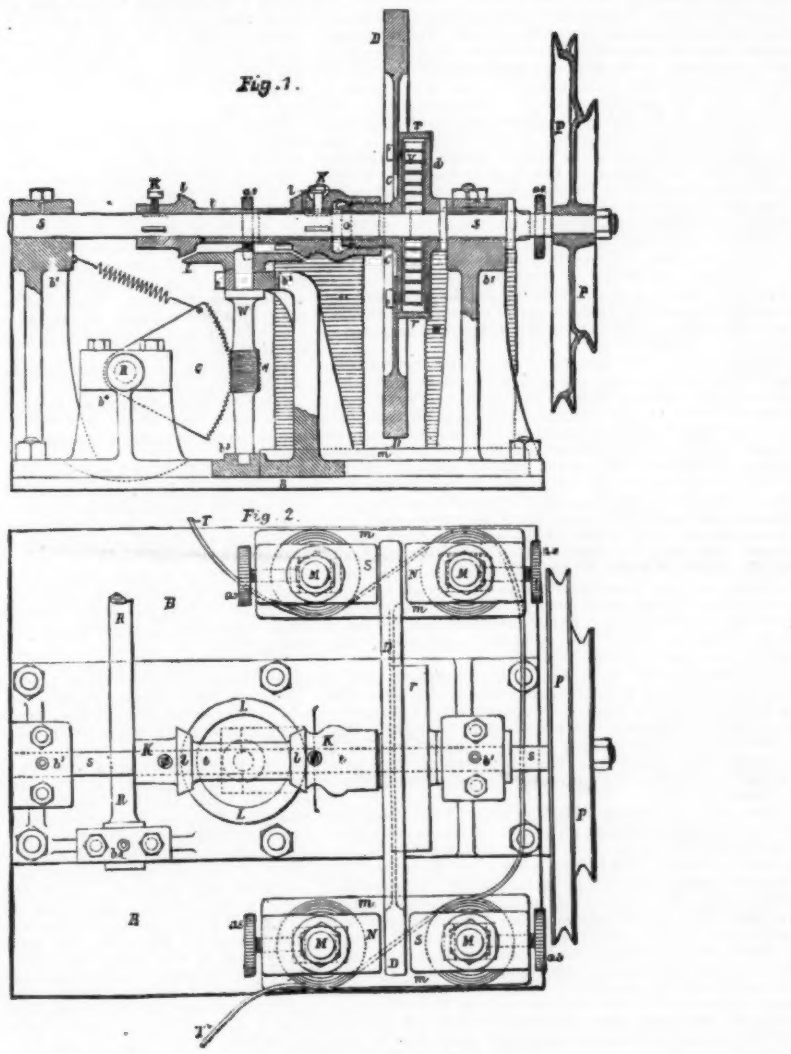
of the machine, but had given it freely to the world. Next he explained the principle of the Leyden jar, saying that in 1745, Von Kleist, a bishop of Cammin, in Pomerania, charged with electricity a flask containing mercury; a nail running through the cork touched the mercury; this apparatus when charged as just stated gave a shock. In 1746, Cunæus, of Leyden, received shocks from a flask in which water was substituted for mercury; he had such a bottle before him, and should be obliged if some boy would come forward to try the experiment. [For some time there was no response to this invitation; at last a boy slowly approached the table, and Professor Tyndall complimented him on his courage, as it did not become an English boy to be afraid. He next informed the lad that after Muschenbrock took his first shock, he narrated his experiences to his friends in Paris, and told them that the sensations were so terrible that he would not take another for the crown of France, but he, the boy, should have one presently. With this encouragement the learned professor handed the bottle to the boy, who took the shock, and returned to his seat.]

JAMIESON'S ELECTRICAL GOVERNOR.

IN a paper lately read by Mr. Andrew Jamieson before the Institution of Civil Engineers, he laid it down that a primary requisite in electric lighting was a good electrical governor, which should automatically open and close the throttle valve in synchronism with the load or work to be done, and leave the valve in its last position until there was a change in the load or in the steam pressure, in order to prevent the breaking of lamps or variations in their light, owing to bad governance or ill-attention to the engine.

Mr. Jamieson exhibited a governor which in conjunction with Mr. Stephen Alley he had devised and tried with good results on board the S.S. Thistle, at Glasgow. It is based, says *Engineering*, on the phenomenon exhibited in Arago's disk, and consists of a copper disk revolving between the poles of an electro-magnet and actuating the throttle valve of the engine by means of a spring and cones. Fig. 1 represents a plan and Fig. 2 a section of this apparatus, where D is the copper disk, fixed on a brass center, C, which is made with a boss fitted loosely on the shaft, *s*. The center, C, has on one side of it a shallow circular box in which there is a volute spring, V, having its center or inner end fixed like that of a watch-spring to the shaft, *s*, while its outer end is fixed to the rim, *r*, of the disk center, C. The outer side of the volute spring, V, is covered by a small disk, *d*, and a collar, *c*, fixed on the shaft, *s*, after the disk center, C, is in its place, prevents this disk from moving along the shaft. The boss of the disk, C, has a screw thread formed on it to work in an internal screw formed in the end of a sleeve or tube, *t*, which is fitted loosely on the shaft, *s*, and can move along it, while it is made to turn with it by set screws, K, acting as keys in longitudinal grooves formed in the shaft. Additional grooves are provided at suitable positions round the shaft to facilitate the adjustment of the parts. The tube, *t*, is made with bevel surfaces, *l*, to act as friction bevel wheels; and to engage with one or other of them there is arranged a frictional bevel wheel, L, on a vertical spindle, W, carried on bearings, b_3 b_3, and provided with a tanget screw, *w*, which gears with a toothed sector, Q, fixed on a rocking shaft, R. When the tube, *t*, is in its middle position, neither of its bevel surfaces, *l*, is in contact with the bevel wheel, L; but when from an alteration taking place in the magnetic resistance to the rotation of the disk, the center, C, moves faster or slower than the shaft, *s*, then the screwed boss of the center, C, causes the tube, *t*, to move along the shaft, *s*, and to put one or other of its bevel surfaces, *l*, into contact with the bevel wheel, L. On this occurring, the bevel wheel, L, is turned with its shaft, W, and the worm, *w*, acts on the sector, Q, and through it moves the rocking shaft, R. This shaft is carried in bearings of which one, b_4, is shown, and is connected to the throttle valve of the engine. The whole apparatus is carried on a base-plate, B, having standard bearings, b_1, which carry the horizontal shaft, *s*. A grooved pulley, P P, is fixed to the shaft, and receives a driving cord from the dynamo axle.

Two pairs of electro-magnet poles, M, are arranged to act on the copper disk, D, being placed with their pole pieces, NS, NS, at opposite diameters. The cores of the magnets and their connecting pieces, *m*, are fixed by screws to the base-plate, B, and the pole pieces are bolted to the tops of the magnet-cores and placed with their inner faces close to the copper disk; adjusting screws, *a s*, being provided for this purpose. Insulated wire for conducting a shunt current to excite the electro-magnets, M, is coiled on the cores in the usual way, being continued from one pole to another in succession, and having its ends, T+ and T−, connected in any suitable manner to the dynamo.



JAMIESON'S ELECTRIC GOVERNOR.

Now when all the lamps, say a hundred, are lighted, and a normal current is passing by the shunt from the main or lighting circuit through the electro-magnets, M, of the governor, the copper disk, D, experiences a certain resistance to its rotation proportional to the strength of the magnetic field, that is, proportional to the shunt current in the electro-magnets. This resistance is balanced by the spring, V, but should any number of the lamps, say ten, be turned out, a stronger current at once passes in the shunt circuit of the electro-magnets, thereby increasing their magnetic field and retarding the revolution of the disk. The speed of the dynamo is also increased by the reduction of the number of lights, and the speed of the disk, which is driven from the dynamo axle, is correspondingly increased. This combined increase of speed and magnetic field on the disk causes stronger Foucault currents to flow in it, and it therefore experiences more resistance, which reacting on the spring is made to close the throttle valve of the engine by a definite percentage. When the admission of steam is thus reduced sufficiently to suit the altered circumstances of the lighter load, the spring reasserting itself causes the friction cones to ungear, leaving the throttle valve in its last position until a change is made in the number of lamps. Should more lamps be lighted, a reverse action to that described takes place. The current in the electro-magnets is reduced, they being in shunt circuit, and so is the speed of the disk; hence for a double reason there is less resistance to its motion, and the spring opens the throttle valve by a definite amount. The governor is said to be quick in action, and does not "hunt."

INFLUENCE OF CIVILIZATION ON EYESIGHT.

AT a recent meeting of the Society of Arts, a paper on "The Influence of Civilization on Eyesight" was read by Mr. R. Brudenell Carter, who said there could be no doubt, not only that the eye, as civilized men now possessed it, was inferior to that possessed by animals which we had far outstripped in other particulars, but also that, among ourselves, it had fallen very decidedly below the standard of excellence which it had attained in some of the families of the human race.

An enormously large proportion of the whole German nation is composed of the wearers of spectacles, and there is abundant evidence that the need for such assistance dated from a comparatively recent period. In 1812 the late Mr. Ware communicated to the Royal Society the result of some investigations into the sight of different classes of people in this country, and he stated that, in the three regiments of Foot Guards, short sight was "almost utterly unknown." During twenty years and among 10,000 men, not a half a dozen soldiers had been discharged, nor half a dozen recruits rejected, on account of it. In the military school at Chelsea, among 1,300 children, he found that there were no complaints of short sight, and, on closer investigation, there were "only three children who experienced the least inconvenience from it." Last year, his friend and colleague, Mr. Adams Frost, was good enough to examine for him a Board school in the south of London, and he found that 73 children out of 267, or rather more than one-fourth, had defective or subnormal vision. Among these 73, 26 were short-sighted, 16 were flat eyed, and would thus be called upon for unnatural exertion in the act of seeing—exertion which cannot fail to tell upon them in after-life, or even before they leave school. In 1865, in Germany, Professor Cohn examined the eyes of 10,060 school children, and found 1,630 of them with eyes of faulty shape. Of these, 1,072 were shortsighted, 139 were flat eyed, 23 were the subjects of a complicated defect of shape called astigmatism, and 396 were suffering from the results of previous disease. He had offered the School Board for London to undertake an equally extensive investigation, but his offer was declined in an uncivil letter, written in very bad English. He could not doubt, however, from the incidental sources of information at his command, that the conditions found in one school by Mr. Frost, would, at least approximately, be repeated in many others. What he might fairly describe as national neglect of the culture of the eyes, and of effort to improve the faculty of seeing, was chiefly due to the prevailing absence of notion concerning the proper range and scope of the visual function, and hence concerning the powers which the eyes ought to possess. Few things were more remarkable than the common want of information about all matters which related to the use and functions of these important organs. In most other respects it might be said that the majority of parents had a fair knowledge of what ought to be the average powers and capabilities of children. They knew, approximately at least, how far a boy of ten years old could reasonably be expected to walk, how high or how far he could jump, how fast he could run, what weight he could carry, what force he could exert. There was not one parent in five hundred who had the smallest notion how large an object—say a capital letter—a boy ought to be able to see clearly at one hundred feet away, or who could tell at what distance he ought to be able to see and describe the characters of an object of given magnitude. There was not one parent in five hundred who could tell whether his children possessed natural color vision, or who, if the inquiry were suggested to him, would know how to discover the truth. Mr. Francis Galton had lately pointed out, with great force and lucidity, that one of the most important duties of man, at the present stage of his development, was to regulate the progress of the evolution of his race; and one consequence of want of knowledge about vision was that the evolution of the eye had been left to the sport of accident, or that it had even been injuriously affected by many of the circumstances incidental to civilization. Into the operation of these circumstances it was now time to inquire. For the organs of living beings there was no resting place; they must either advance or deteriorate, either continue in a course of improvement under the influence of evolution, or "throw back," as breeders say, to an earlier and less finished type under the influence of sluggish and imperfect use. Of deterioration we had an abundance of examples, and in two especially common ways.

We had the malformation of short sight, which had come into existence within historic time, and into prevalence almost within living memory, and which now affects a least one-tenth of our population; and we had the malformation of flat eye, which was plainly an involution, a return to an earlier and less perfect type, and which was attended, in the great majority of cases, by an acuteness of vision below even the humble standard with which our dwellers in towns are wont to satisfy themselves. The remedy for the conditions which he had described must be sought, first of all, in a recognition of the fact that good sight is an important point of physical excellence, which like any other such point should be assiduously cultivated. He would urge parents to ascertain, as soon as their children knew the alphabet, whether they could decipher the letters at the proper distances. He would urge upon them, in the case of every child whose vision was subnormal, to ascertain the cause and nature of the defect, and to regulate not only the studies, but also, as far as possible, the future career, in accordance with it. He would urge upon all who had the control of schools, that the vision of every new pupil should be tested on admission, and that the tasks required should be controlled in accordance with its capabilities. He would urge that all lesson books for very young children be printed in large type, and that the children should be compelled to keep such books at a distance (the type in which we often see texts of Scripture printed to be hung up in railway waiting rooms would be a good size for the purpose). He would urge that many of the school books now in use should be abandoned, and that new editions should be prepared, in type of at least twice the size and twice the legibility (the latter depending much upon the shape and design of the letters) of that which was now in use. Finally, he would urge upon all who were concerned in the organizing of athletic sports and contests that excellence of vision should be highly esteemed in such competitions. He felt sure that, if public attention were once fairly di-

rected to the question, if the eyes received as much attention as the muscles, and if an intelligent knowledge of what they ought to accomplish were diffused abroad, our country, in the course of two or three generations, would be peopled by a race who might engage, if not without fear, yet certainly without disgrace, in a seeing contest with any other representatives of the human family.

PROFESSOR EWING ON "HEALTHY HOUSES."

A lecture on the above subject was recently delivered at Dundee by Professor Ewing.

He said: Just a year ago you listened in this hall to a very remarkable lecture on the duration of life in Dundee and the causes which influence it, by Dr. Anderson, our able and enthusiastic Medical Officer of Health. I never heard a more powerful plea for sanitary reform than Dr. Anderson laid before you. He analyzed the vital statistics of the burgh, and compared the average age at death of persons (men, women, and children) belonging to the working class with the average age at death of men, women, and children belonging to the wealthy and professional class (two terms which I have good reason to know are not synonymous). In the wealthy class the average age at death was nearly 53 years; in the working class it was only 24 years. And this enormous difference was due chiefly, though not wholly, to the deaths of young children in the families of workingmen. Of all the deaths among the working classes 24 per cent., or close on one-fourth, were children under one year old, and 44 per cent., or not far from one-half, were children under five years old; whereas in the wealthy class the deaths among children under five years were only 15 per cent. of the whole deaths in that class. He told you, moreover, that there was no reason in the nature of things that a working-man's children should die three times as fast as his better-to-do neighbor's, but that this enormous mortality is essentially due to preventable causes. He told you that while a prisoner in jail has 800 cubic feet of air allowed him as necessary to his health, the Dundee ratepayer who pays for him has in most cases less than half as much for himself and his children. He told you that he did not believe there were more than 240 houses in Dundee whose house-drains were perfect. And then he described the condition of 166 properties which had been examined within one year in consequence of the occurrence of infectious disease. He told you of their defective closets and unventilated soil-pipes and leaky drains and unsealed traps—of defects which were more than sufficient to explain the cases of typhoid and diphtheria which had occurred in these houses. And what I want to tell you to-night is this—that if you go home and look to your own pipes and fittings, there is scarcely one of you who will not find as grave defects as were found in these plague-stricken dwellings.

Not many months had passed from the date of Dr. Anderson's address till the Dundee Sanitary Association was at work. Our engineer, Mr. Fleming, and our secretary, Mr. Tosh, have now been carrying on the work of the Association for nine months, and the inspections already made have fully justified the existence of the Association. There were some last year who called Dr. Anderson's lecture sensational and himself an alarmist. Sensational it certainly was in the sense in which a colliery explosion or an epidemic of cholera is sensational, but if one year's experience in the houses of Dundee merchants is to be accepted as a guide as to what is to be found in the houses of our working-men, I fear that Dr. Anderson rather understated his case. To-night we are to approach the subject from an engineering point of view, and consider what conditions we should aim at in our houses to make them healthy, and what elements of danger we have to confront. Our complex town civilization has given us houses which are connected to a vast underground network of pipes and drains. We have pipes and drains for the removal of excrement and other foul matter, pipes for the supply of water (not to speak of gas). These not only come to our doors, but penetrate into the rooms we live in and sleep in; and while we have learned to regard them as indispensable adjuncts to our houses, it would be folly to shut our eyes to the fact that they involve great possibilities of danger.

It is only by seeing clearly where their danger lies that we can make them harmless. The essential conditions of a healthy house lie in two little phrases—"pure air" and "pure water." How then can we arrange the drains and pipes of a house so that the water we drink and the air we breathe may not become tainted? From the houses of a town is constantly pouring forth into the sewers the refuse of life—all the material which medical men teach us to be the most ready medium for the transport of disease. If we had a community which was perfectly healthy, it is at least probable that their refuse would be harmless; but the case is very different when we are dealing with a community of whom some of the members are already diseased. We must then treat the sewers as tainted with matter which is really poison, as containing multitudes of germs which, if they find a fruitful soil, will ripen into fresh disease. This is true not only of the liquid contents of the sewers, but of the air and gas above them. From the nature of its work, a sewer rarely runs full. The term "sewage-gas" means the air which is brought into contact with sewage, and which consequently receives pollution from it. It is a subtle form of danger, which comes not only to our door, but invades almost every room in our houses. To breathe air or drink water that has been tainted with sewer-gas is a potent cause of disease—always deleterious and often fatal.

The first problem, then, which we have to face is how to prevent the entrance of sewer-gas into our houses. It has been found that the common or S trap does not always act effectively. The seal may be broken by the pipe bending, by the evaporation of the water, by the water being reduced by siphonage in consequence of threads hanging over the bend, or by the gases forcing a passage through the water. The first cardinal point, therefore, to which we have to direct our efforts is to begin to shut off all the sewer-gas at a much earlier stage, instead of trusting to the seal within a few inches before it enters our respiratory organs. This is accomplished by means of a disconnecting trap outside the dwelling, which prevents the sewer-gas entering the house at all, and, besides serving as a water-trap to keep out the sewer-gases, it also acts as an opening for the admission of fresh air to help in ventilating the drains. This is an important consideration, for it has been found that the germs which give rise to the deadly character of sewer-gas cannot live permanently in an atmosphere containing much fresh air. There are different forms of disconnecting traps, and the one we generally recommend is that known as the Buchan trap.

With reference to the water-supply, it is desirable that it should be drawn directly from the main, and not from a cistern. The pan-closet used in many houses is the most complicated and worst that can be used. What is known as the "washout closet," in which there are no metallic parts, is much preferable. One of the most important sanitary defects is the leakage of pipes which are intended to be tight. In London and some other cities it is a common experience to find houses in which there is actually no proper outlet for the sewage, and consequently all that leaves the house simply sinks into the soil under the basement. The important points about the sanitary arrangements of a house I would summarize under seven heads: (1) The disconnection from the sewer; (2) ventilation of the soil-pipes; (3) that the soil, drain, and waste pipes be air-tight and watertight; (4) that the discharge from bedrooms and pantries should not enter the soil-pipes, but discharge over an open trap outside the house; (5) that every pan fixture shall have a proper water-trap; (6) that the overflow shall go right out to the open air, and not be connected with the drain system of the house; (7) that the plumbing fixtures shall be clean and effective in themselves.

There are many reasons why drain-pipes and plumbing-work become defective in the course of time, consequently the only security that a house shall remain in good condition is that it be periodically inspected. Who is to make this examination? Can we expect it to be done by public officials? Perhaps under the present system of local government that is impracticable. One sanitary inspector, however energetic, can only overtake a limited number of houses. If the inspection is to be thorough, I believe it would be necessary for such a town as Dundee to have a small army of trained inspectors to go over the whole burgh. Even supposing the ordinary householder had the requisite knowledge, he would prefer a technical expert to do the work for him. To call in a sanitary engineer on one's own account would be very expensive, but a satisfactory solution of the difficulty has been found by the establishment of the Sanitary Co-operative Protection Association, a branch of which has been started in Dundee.

I shall give you the results of the Sanitary Association's work in the examination of the best houses in Dundee. The largest houses in the town were built before the time of the sanitary reformation, when it was considered rather a luxury to have a great number of sanitary fittings in a house. In the houses examined were a multitude of the very gravest defects. Forty per cent. were very bad. Only one house in six was found to have the first essential of correct sanitation—a disconnecting-trap between itself and the sewer. In 66 per cent. alterations have been actually gone about. There is one house in Dundee in which the drainage arrangements are perfect—the house of your president, Mr. Kyd; and this is primarily due to the fact that his brother is one of the engineers of the London Sanitary Protection Association. These statistics tell us something of what is called "sweet home," and prove that home is not always sweet in a sanitary sense.

In a recent lecture here, Mr. Matthew Arnold told us that those kinds of knowledge are most valuable which can be most directly related to our sense of conduct or our instinct for beauty. I am obliged to admit that the knowledge I have been endeavoring to impart is not easily related to any instinct for beauty, but I hope you will see it has a very direct bearing on our instinct for conduct.

There is much strong language used about plumbers and about landlords very unjustly. Plumbers do pretty much what they are told to do, and landlords supply what tenants are willing to take. It is on you that the responsibility of living in unhealthy houses ultimately rests. I do not envy the moral consciousness of a landlord who knowingly supplies a tenant with bad drains, nor that of a plumber who deliberately scamps his work, or who, though working honestly, allows himself to remain ignorant of the principles and practice of sound sanitary plumbing. But for every one man who is blameworthy for reasons such as these there are hundreds who keep their own lives and the lives of their wives and children in jeopardy from day to day by living in a blind and thoughtless faith in the supposed sanitary excellence of their uninspected dwellings. All experience teaches that, with few exceptions, houses built even a few years ago have serious sanitary defects. All experience teaches that, even when well planned and well constructed, the pipes and fittings become faulty in time. All experience teaches that faulty drainage arrangements are a fertile source and ready vehicle of disease. And yet there are probably few men present who are not ready to drift on in a careless confidence that their several dwellings are exceptions to the almost universal rule. There are many men who will not be roused out of this sleepy optimism by anything less violent than the inroad of disease; but there are, perhaps, a few who will be stirred to inquire whether the place they call home is, in this most essential respect of healthfulness, fit to be the habitation of those they hold most dear.

NATURE'S HYGIENE.*

The accomplished chemist whose book found a good reception four years since, has found it necessary to rewrite the greater part of it, and to add several new chapters dealing with water supply, sewage, infectious diseases, and the treatment of the sick. He takes the opportunity of suggesting that chemical officers should act in conjunction with medical officers of health, entertaining, as he does, a conviction that a saving generally would be effected to the ratepayers.

Dealing in the introductory chapter with the constitution of matter and the chemical composition and properties of the air, Mr. Kingzett proceeds to consider the nature of oxygen and ozone, the requirements of respiration and ventilation, and the sanitary bearings of oxidation, physiological combustion, natural decay, and putrefaction. Under the head of Water Supply he treats successively on sewage contamination, oxidation in running streams, and the purification of water by filters. The sixth chapter is a fairly trustworthy summary of the merits of the different means of sewage disposal, if we except the expressed opinion that there is little difference between broad irrigation and intermittent downward filtration, and that, on the whole, ordinary irrigation is to be preferred. We differ here from Mr. Kingzett, believing that in intermittent filtration, sensibly applied, a solution is to be found for most difficulties in the way of sewage disposal. The chapter on contagious diseases is an interesting one, and the claims to credence and objections to the different theories of disease are fairly set forth. The chapter "How to Prevent Disease" is perhaps the most practical in the volume, and we quote the following extract:

"Many investigators are of opinion that each infectious disease is originated (indirectly of course) by one particular microbe, but morphological investigations can scarcely be said to have given an adequate proof of this contention, and in any case it would be hopeless to attempt the universal extermination of micro-organisms which originate disease, for they are apparently ubiquitous, and constitute an order in creation. Collectively, indeed, they constitute a most useful and necessary order in creation, for by their agency, or that of some of them, putrescible organic matter at large is converted by hydration and oxidation into innocuous and useful, nay, essential, ultimate products. But while it is injurious to have the micro-organisms of putrefaction at work in our houses, it is even more prejudicial to health to have them or others at work in or upon our bodies. If they effect a residence in or upon the human body, and the conditions necessary for their reproduction be present, disease results, and death may supervene.

What chemical means and agents, then, are to be employed for the prevention of such diseases?

They are both general and special.

The general means include cleanliness; the studied exclusion of putrescible matters and processes in and around human dwellings, and a due provision of pure air and pure water. Every medical practitioner and every sanitarian, irrespective of favorite theories as to the causation of preventable disease, is assured of the help which filth and insanitary surroundings give to contagious illnesses. That being so, every chemical reagent which admits of being usefully employed in insuring chemical purity is a disinfectant in the best sense of the word.

Liebig pointed out that miasmatic diseases are endemic in places where the decomposition of organic matter is constantly taking place, as in marshy districts, and that these diseases become almost surely epidemic when a marshy area is dried up by continued heat.

Besides this, it is known, with certainty, that some animal substances, in a state of decomposition, can excite a diseased action in the bodies of previously healthy persons. This is often experienced in anatomical theaters; the slightest wounds made with instruments which have been used in dissecting putrefied bodies not rarely lead to dangerous and even fatal results. In such cases, poisonous matter is communicated to the blood in the living body, and, even in such infinitesimal amounts, is capable of producing the most terrible results.

Mr. Haviland, who has made a special study of the geographical distribution of disease, writes as follows: 'Typhoid fever has no reason for existing at all, but while the porous soils of the sites of our villages are being polluted as they are, we must expect well-contamination and its sequel—fever. One great source of well-pollution, which I have known to be the origin of much fever, is the farmyard and its manure heaps. At present, the rural sanitary authorities are generally composed of farmers and others who cannot, or will not, see anything wrong in their barbarous muck heaps. The medical officer of health sees their effect daily. The effect of vegetable decomposition on the human system is varied, but marked. Let us take first the decomposition which produces ague and other forms of fever, as witnessed in the fen lands, the Pontine marshes, and in other swampy grounds. Or remember the peculiar fever that is the result of living near the localities where flax is steeped and decomposed, or where indigo is allowed to ferment. Then, again, we must not forget that during the American civil war, some few years ago, a form of fever arose, simulating measles, which was traced to the decomposition of the straw on which the soldiers were bedded.'

Attention has already been directed to the peculiar infectant which is contained in putrilage, and which Burdon Sanderson has shown to be of a particulate non-living nature. It is a most virulent blood poison, and must, from the method of its production, inevitably attend as a product of the putrefaction of flesh wherever this may occur. This being the case, it is most probable that its formation also results from the putrefaction of other animal and vegetable matters containing albumen, since its production from flesh is traceable to the same chemical principle. Sepsin, as this poisonous matter is termed, is a mere chemical product of change capable of exerting a physiological effect in the same manner as hundreds of other chemical substances exhibit peculiar physiological effects. Thus, the inhalation of chloroform produces insensibility to pain, and if taken in excess, results in death. Similarly, if a septic poison be received into the system, it will produce effects which, when recognized, are expressed as fever, and from which death may result.

It may also be borne in mind that many years ago Dr. Semmelweis established the fact that a number of deaths occurred in a lying-in-hospital at Vienna from the conveyance of putrescent matters to the genitals of the patients in an extraordinary manner. The physicians in attendance on the women were largely employed in dissecting, and it was known that these same operators would often leave the dissecting-room to examine women in labor, and thus introduce on their hands the poisonous matter, which led, in so many cases, to puerperal fever, and finally to death.

It is true that the precise connection of all this with infectiveness is not quite so clear as might be wished; but we are left in no kind of doubt that at least many, if not all, infectious diseases have their origin in putrefactive and allied processes, and that sepsin is to be regarded as the type of an infectant.

It may, indeed, be taken for granted that the whole

* Nature's Hygiene. By C. T. Kingzett, F.I.C., F.C.S. London: Baillière, Tindal, and Cox. (Second edition).—*Building News.*

experience of the world in all ages goes to show that much preventable disease originates in the putrefaction of animal and vegetable matter going on in the midst of human habitations.

Hence, in sanitary practice we aim at preventing putrefaction under given conditions, and the agents employed to prevent such processes are termed antiseptics. Indeed, an antiseptic may be defined as a substance which, when properly applied, prevents the formation of septic poisons in its vicinity. Such substances are also not rarely termed disinfectants, and indeed it seems clear that if putrefactive change gives rise to infection, then agents which will either prevent or arrest this process may be fairly termed disinfectants.

Dr. Gamgee, writing on this subject, says: 'I am now convinced that every good antiseptic is really a destroyer of disease germs; an arrest of development is insured.'

If a beefsteak be placed in contact with air and water and allowed to putrefy, the resulting product constitutes a most virulent fever-producing product; but if we place with the beefsteak a certain quantity of antiseptic material, the putrefaction does not occur, and the poison is not formed. This is clear, and it is certain. Moreover, it is probable and almost certain that the poisonous matter, even if it be allowed to form, may be afterward destroyed by certain other chemical substances which have the power of oxidizing and burning it up, just as all the organic matter in nature is oxidized and burnt up under ordinary atmospheric influences.

The special means for the prevention of infectious disease are of the same order, but resolve themselves into the use of antiseptics or disinfectants more locally, and, if possible, at the seat of disease, with the object of avoiding the results that follow from the unimpeded development in the human body of the micro-organisms upon which disease depends.

Unfortunately, these microbes, or some of them, exhibit very tenacious powers of resistance, and some of their spores, at least, survive the application of parasiticides, even if employed of sufficient strength to poison the patient (host). The fully-developed micro-organisms are more amenable, however, to such reagents than are the spores or immature germs to which they give rise, and by which they are reproduced in successive generations.

We must include, then, among disinfectants those substances which destroy the life of microbes (irrespective of kind; for whether any one parasiticidal agent is fatal to all kinds of micro-organisms is yet unascertained). Among such substances are peroxide of hydrogen and permanganate of potassium (which are at least fatal to anaerobes generally), and thymol, iodoform, corrosive sublimate, chloral, and phenol, each of which acts destructively, to certain classes of micro-organisms, and particularly aerobes.

The application of such chemical reagents to putrid mixtures results in the cessation of putrefaction, and the reason why such application remains efficacious is either that the presence of the chemicals prevents the development of further spores into the mature state, or else that they kill each organism as it is developed. They act in the same way toward the microbes that initiate diseases.

The precise mode of action of disinfectants must necessarily be various in character. It is possible, for instance, that peroxide of hydrogen acts as a direct poison to anaerobic germs of the putrefactive type. It may asphyxiate microbes, that is to say, by its active oxygen, just in a similar way to that in which carbolic acid acts as a direct poison to man. Preparations such as pyrogallic acid may act in the directly opposite manner, viz., that of absorbing the oxygen necessary for the life of some microbes. Other chemical reagents, such as tannin, may render the medium in which the micro-organisms exist unfit for their further sustenance, by entering into combination with the albumen upon which they may have hitherto depended for food, thus converting it into a substance which they cannot decompose. In this way they may be starved out of existence. Or yet again, just as a man may be anæsthesiated by chloroform or ether, so also may be micro-organisms. Thus, Claude Bernard has shown that the sensitive plant loses its irritability when placed in contact with the vapor of ether, but regains it if the ether be removed. If not removed, the plant dies. Again, if the yeast plant (which is a type of disease-organisms) be placed in an etherized sugar solution, it will no longer act as a ferment, and ceases to be reproduced until and unless the ether be removed. If not removed, the cells succumb to the ether, and finally die.

It will be evident, then, that there are more ways of destroying disease germs or microbes than that of the doubtful process of direct attack. They can be starved out of existence, or they may be anæsthesiated, or the general conditions surrounding their existence may be so influenced that further life becomes impossible. Collectively, all chemical agents, which lead by their employment to the death of the micro-organisms which breed disease, are disinfectants in the only true sense. It is also perfectly conceivable that many chemical reagents may exercise such an influence over microbic life that, without destroying it, its functions may be so diverted as to be carried on without danger to health in the body of human beings. That is to say, instead of poisonous products, innocuous ones may be formed by their life-functions. Heat is not a disinfectant, but a disinfecting agency.

Prevention is better than cure, for if the microbes of disease obtain access to the muscles, or the blood, or the bones, then the host may first succumb to the chemical reagents that are used with the view of destroying the parasite alone. The use of disinfectants for internal administration greatly limits their available number, and this is a subject that has received far too little attention. The only direction in which it can be said to have been tried at all is in connection with the treatment of throat and lung complaints by a process of inhalation. There are many who think with Drysdale, that probably the best means of protecting persons against such diseases as small-pox, will be found in the extended art of vaccination, and that the most efficient treatment of other diseases, such as ophthalmia, is the practice of inoculation. Unfortunately, we are without any accurate information as to the manner in which these practices confer protection or immunity.

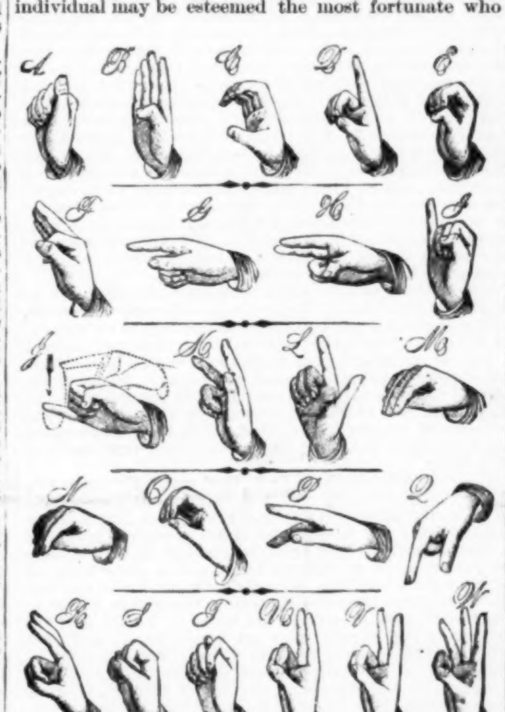
In the use of disinfectants for the prevention of parasitic diseases (in contradistinction to their cure), regard must be had also to their general characters and their influence on health.

Dr. R. Angus Smith has said tersely enough, 'We live in air, and the air flows continually into our blood; no wonder, then, that we are influenced by climate, which means the condition of the air.'

Carbolic acid, for example, is a deoxidizing agent which, when added to the air, vitiates it both by diminishing the available oxygen and by its mere poisonous presence. Similarly, sulphurous anhydride uses up useful and life-giving oxygen by becoming oxidized into sulphuric acid.

For univeral use a disinfectant must have the following characters:

'First, it should not be dangerous if by any chance it be taken internally, and we know that in the case of carbolic acid, for instance, fatal accidents from its use are of constant occurrence. Secondly, it should not be destructive of any substances to which it is applied, as such a quality would necessarily limit its action, and it could not be used, as noted above, to saturate sheets and cut off infection. Thirdly, it ought not to be offensive, for, even postulating the efficacy of an evil-smelling disinfectant, it is never likely to become popular, and it is to the general, we might almost say the universal, use of disinfectants that we must look for any permanent mitigation of the evil exhalations that so often pollute the atmosphere, and which almost invariably carry with them the germs of disease. Many disinfectants offered to the public fulfill one or two of these requirements; while others, though effectual enough, contain recognizable elements of danger. Only one or two may be used with confidence wherever a disinfectant is needed, always remembering that as a nation is reputed happiest which has no history, so that individual may be esteemed the most fortunate who



ALPHABET OF THE DEAF AND DUMB.

manages so to purify his premises and order his household as to have no need to use a disinfectant at all."

Mr. Kingzett claims that the only disinfectant possessing all these characters, and which also acts on anaerobic and aerobic life alike, is Sanitas, of which he is the inventor, and which we believe is now manufactured and sold in very great quantities, and is coming more and more into use. We have before made our readers acquainted with the composition and merits of "Sanitas," and must refer those desirous of information to Mr. Kingzett's exceedingly well written and interesting work.

THE POTTERY OF THE MOHAWK INDIANS.

THE strip of territory in the State of New York where the strongholds of the old Mohawks were situated in prehistoric times, as well as their villages of the 17th and 18th centuries, is of small extent, being not more than thirty miles long, and mostly included in the present county of Montgomery.

Here were their palisaded towns, their cornfields, their fishing places, their open air workshops; this the eastern door of the Long House of the Iroquois, and here the grim Mohawk sat, the fiercest one of all the Five Nations, the terror of the native tribes and the scourge of the infant colony of New France. The lakes, the streams, and the pathless forests of the Adirondacks were his hunting ground and special preserve, from which he drew those vast stores of beaver and other furs that caused such strife between the French and Dutch. The early chronicles of these nations are full of the atrocious deeds of the Mohawks, and the "Relations" of the Jesuits are voluminous records of the "Mission of the Martyrs," but their home life and native industries are but casually hinted at, and can only be illustrated and brought to light by digging in the debris around their old villages.

Being the chief tribe in a confederacy so celebrated, and advancing slowly toward civilization, it is interesting to study anything relating to them.

The sites of their villages are very numerous, and the relics found on these places throw much light on the manners and customs, trade, commercial intercourse, and artistic sense of these people. These sites naturally divide themselves into two classes—the prehistoric villages, and those that were occupied at the time and after the discovery. I shall have space only at this time to speak of the oldest of these village sites, where the tribe lived when they were entirely in their stone age; for I assume, after much investigation and study of the subject, that all the town sites found in the ancient Mohawk territory were occupied by this tribe. It cannot be shown that any other people lived here before the advent of the Mohawks, for the relics found indicate a common origin from one people. I know that this has been doubted, and even denied. Squier and Davis, in "The Ancient Monuments of the State of New York," claim that the most eastern point reached by the "Mound Builders" was the village site which they describe near Fort Plain, in Montgomery County. I am familiar with this place, having spent much time there, and have in my collection hundreds of relics taken from the refuse heaps, and I have failed to find the least indication of any other people than the Mohawks, in their prehistoric and stone age state. Squier and Davis were certainly at fault in regard to their place, for although they relegate it to the "Mound Builders," on account of the earth-work and ditch thrown across one end of the site, they still make the remarkable statement that axes, guns, and other articles of European manufacture have been found there. In all my investigations of the place I never have found anything of the kind. But if this *was* an outlying village of the people they describe, they were again in error in saying it was the most eastern, for there is another site of exactly the same character, yielding relics of the same kind, about fifteen miles to the eastward.

This site has long been known, as all such places are, by the name of Indian Hill, and for the sake of convenience I shall call it Ga-ro-ga, it being situated on a stream of that name which is one of the affluents of the Mohawk. This village site is remarkable, being beautiful for situation, and yielding from its great refuse heaps an abundance of most curious and interesting relics. The place chosen for this stronghold was one of those high round knolls which the Scotch call kames. It is a hill of sand about one hundred feet high, with a flat top, containing about five acres of land. The sides are very steep, and it is bounded on one side by the Garoga Creek, and commands an extensive view of all the surrounding country. At the time it was discovered a dense forest of pines covered the whole of it, and the holes where the palisades once stood could be seen. All the villages of the Mohawks were in the early time surrounded by these defenses, as many as five rows of pickets being used, the highest being as much as thirty feet in some instances, and being so placed as to afford perfect protection to the village within the inclosure.

Although the relics of bone and stone and clay are very numerous at this place, it is only with the fictile ware that I shall deal with at this time. No Kjokkenmodding of Denmark, or kitchen-midden heap of any other country, has yielded more relics from the same space than have these deep piles of ashes around this old village of Garoga; by the aid of a collection of these things, we get a glimpse backward into the life of these people. We see a tribe of stone age men; their axes, hammers, knives, and arrow heads are of stone, their needles, awls and ornaments are of bone, and mixed with the ashes of their fires are the bones of the animals they killed, and also the corn and beans that they cultivated. But more abundant than all else are the fragments of their rude archaic pottery, which notwithstanding its primitive character has yet a certain grace of form and originality of design that compares favorably with the earthenware of any other rude people, made by hand before the potter's wheel was known.

The pits from which the clay was taken are at the foot of the hill on which the village stood; they are abundant all along a little stream that trickles over the huge bowlders and logs and through a tangle of ferns and wild growths of all kinds. The holes were sunk through the upper soil to a bed of stiff, tenacious clay, which overlies the Utica slate to a great depth at this point.

There are many descriptions in the old writers of the way the Indians manufactured their pottery; and from the appearance of the innumerable fragments found at this place, the Mohawks made it as the other tribes did. The clay having been procured from the pits, it was thoroughly kneaded and intermixed with pounded shells or silicious rock or sand, moulded by hand into the desired shape, ornamented, and baked in huge fires. One peculiarity of this pottery is, that the ornamentation is almost invariably a series of incised straight lines, monotonously reiterated and rearranged in a variety of similar patterns, not a circle or a curve; and only in one instance that I have found any attempt at a departure from the accepted Mohawk style of decoration. This is shown in a fragment of a jar, the rim of which was somewhat square, having upon each corner the rude figure of a man. This uniformity of decoration and absence of animal figures on the pottery seems to be strange, for their clay pipes are wrought with great skill, and the figures of many kinds of animals and the human face are often wonderfully well modeled.

Occasionally, fragments are found which show plainly that the jar was moulded in a basket after the manner described by Hunter (Hunter, Manners and Customs of Several Indian Tribes, Philadelphia, 1823): "Another method practiced by them is to coat the inner surface of baskets made of rushes or willows with clay, and when dry to burn them; in this way they construct large handsome and durable ware." Many fragments of jars are found, evidently made in this way, for all the lines and cross lines made by the twigs are plainly impressed in the clay.

I once took a very small jar of very small size from an Indian grave which dated probably about the middle of the 17th century. I am able to approximate closely to the date from the associated articles found with this jar: European clay pipes bearing the marks of certain known English makers—the Mab pipes, Danes' pipes, and old man's pipes of the English archæologists—and a perfect jug of Fulham ware, resembling closely Gres de Flanders. This little cup is beautifully made, and is

ornamented in a peculiar way. It is very small, and might have been a child's toy, only that it was found in the grave of an adult. Little toy jars are sometimes found, evidently made by using the end of the finger as a mould over which a base of clay was spread, a few scratches being made by way of ornament with the finger nail, and then baked as the other ware was. Toys of various kinds seem to have been made by the Indians for their children, and are sometimes found in the refuse heaps. One of these little cups is remarkable on account of its great similarity to the copper kettles that the white traders brought in so many years afterward. The ears with holes through them for a handle, and its shape, are like a very small copper kettle I have, and which was found on the site of a village of a late date.

This pottery of the Mohawks was invariably round on the bottom, and whether the jars were large or small, they were made with a heavy projecting rim, around which a cord could be wound to suspend the jar or to form a handle by which it could be carried.

The fragments of this pottery are the most numerous at Garoga and other prehistoric sites, but continued to be made, with no variation in shape or decoration, but in continually lessening quantities, as the tribe was brought more and more closely into contact with the traders; then the copper kettle superseded these primitive jars just as the trade ax did the stone one, and copper arrow heads those of flint, until finally, at about the time of the Revolution, all knowledge of these native primitive industries was lost, and the Mohawks, from being an independent self-supporting people, came to be dependent upon the whites, for all of their utensils, clothing, and arms.

What the Mohawks' destiny would have been had the white man's advent been postponed a hundred years longer, and whether they would have advanced toward a civilized life, it is of course impossible to tell; but from what we know of them, it is not improbable to imagine that they would have advanced, and shown an original, autochthonous society, much more elevated than they were at the time they were first known to the European.

S. L. FREY.

THE HORSE OF KABAH.

ITS VALUE AS A PROOF THAT THE RUINED CITIES OF YUCATAN ARE OF MODERN CONSTRUCTION.

ARE the ruined cities of the Mayas, found scattered throughout the forests of the Yucatecan peninsula, of modern construction, as Mr. Charnay pretends? Are they of the seventh century of the era vulgar, or anterior to that time? What do you know about the horse that Mr. Charnay affirms having seen sketched on the walls of one of the palaces at Kabah?—are questions that several of my correspondents have addressed to me since Mr. Charnay's publication of what he calls his greatest discovery.

On seeing controverted the question of the antiquity of the admirable edifices that the Mayas have left behind them as mementoes of their passage on earth, and that by Mr. Charnay, after being informed of the facts contained in my essay, "Vestiges of the Mayas," published in New York two years ago and dedicated to his patron, Mr. Pierre Lorillard, I considered it a loss of time to refute such assertion, founded on so futile a base, as plausible a *fact* as the ruined palaces of the Toltecs that this explorer pretends to have discovered in the valley of Mexico, which are mere phantoms, offsprings of his imagination, worthless as far as history and science are concerned, as can attest the professors of the National Museum of Mexico, and others who, like myself, have visited the spots and know all about the matter. Since, however, such students as Mr. Ignatius Donnelly, who has published a most interesting work, full of erudition, about *Atlantis*, and others who like him have dedicated themselves to the study of American archæology, have believed implicitly and in good faith these relations, taking them for true, have founded upon them part of their theories, I have thought it not out of place to relate some *facts* in regard to the pretended sketch of a horse mounted by a Spanish cavalier, a faithful tracing of which I herein give, in order that my readers may judge for themselves.

Mr. Charnay in various publications, as much in this country as in Europe, has exerted himself to prove, because of said *sketch of a horse*, that the ruins existing in the peninsula of Yucatan cannot be anterior to the seventh century of the era vulgar.*

If we examine their architecture and mode of construction, we shall find that they have many points of resemblance with the architecture and mode of construction of the monuments of the Egyptians, of the Chaldees, of the Greeks, of the Etruscans, and of the ancient inhabitants of Cochin-China. This perfect similarity cannot be altogether accidental.

The arch *en encorbellement*, or triangular arch, the only one in use by the builders of the temples and palaces of Mayax, is constructed according to the same principle by the architects of the magnificent temple at Angcorwat, visited by a French commission of scientists under the command of Capt. Lagree in 1866–68, as those seen in the tombs of Mugheir in Lower Mesopotamia, as we are informed by Loftus, Layard, Rawlinson, Botta, Rassam, and other explorers of the ruins of Nineveh and Babylon. Mugheir is the ancient *Hur* of the Chaldees, which according to the Bible was built about the time when the patriarch Abraham lived. This same triangular arch forms the vault of the passage that leads to the King's chamber, in the center of the great pyramid at Ghizeh, in Egypt. Computations assign its construction to about the middle of the fifteenth century before the Christian era. It is also seen in the archaic monuments of Greece and Etruria; in the treasure room of Atreus at Mykene; in the room built by order of Minyas, King of Bœotia, in Archemenes; in the monuments of Tiryns; among the Cyclopean walls of Arpino in the territory of Naples, which are of Etruscan construction.

The form of the most primitive monuments of the Yucatecan peninsula is similar to that of the most ancient mounds at Angcorwat and those of Chaldea. They consist of three superposed platforms, built *en retrait*, that is, the one above is smaller in a certain proportion than the one immediately below, they have exterior stairways, and the most elevated platform sustains a temple, as in Mugheir or in Chichen, or columns of Katuns, as in Ake; their sides or their angles invariably corresponding to the cardinal points. In after times the number of terraces was increased to seven, even to nine; the edifices then acquired the pyramidal form, as we see them in Hindostan, Egypt, Mayax, and many other places.

In Mayax, as in Egypt and Chaldea, the history of the builders is written on the walls, either interiorly or exteriorly, of their constructions. The inscriptions on those of Yucatan are composed of quadrilaterals that inclose the words or sentences, as is seen in the most ancient inscriptions of the Chaldees; but in Mayax a great number of signs are identical with the most ancient of the Egyptian alphabet, as we see it reproduced in the works of Champollion, Jr., Rouge, and others.

Like the Egyptians and the Chaldees, the Mayas traced or sculptured on the walls of their temples their calendars and cosmogonic myths, as, for example, in the east facade of the temple of Chichen, where the picture of the creation of the world is seen, exactly as we find it described at the beginning of the first book of the Laws of Menu—a work compiled, according to Colebrooke, William Jones, Burnouf, Gauthier, and other learned Indianists, 1,300 years before the Christian era, from other works anterior to that time. We read in the works of the historians Eusebius and Porphyry the account of the creation as taught by the Egyptian priests, and how they represented the Supreme Intelligence and the Creator. Their relation seems a description of the sculpture of the Maya artists.

It would be easy to multiply facts to show the complete identity of ideas and conceptions that existed, or appear to have existed, between the architects of the most ancient buildings of Mayax, Chaldea, Egypt—identity so surprising that it causes us to believe that if the construction of the monuments of Mayax does not antedate that of the other countries, it is at least coetaneous, notwithstanding the vast expanse of land and water that exists between the respective countries, and that in spite of the distance they must have been intimately connected. The comparative study of the plans of these edifices is enough to convince one of the evident truth of the *fact*. This needs not science; common sense only. I may add that the names of many of the cities of the Mayas were the same as those of some of the deities worshiped by the Egyptians, as, for example, *Ake*, *Panuba*, *Ho* or *Hu*. *Kabah* itself is one of the names of Seb, the father of Osiris, one of the principal gods in the valley of the Nile.

On studying the drawings that Mr. Catherwood, who accompanied John L. Stephens in 1842, made of *Kabah*, and recognizing among other ornaments the mongrams of King *Can*, the father of *Coh*, and founder of Uxmal, I became convinced that *Kabah* had been a place dedicated to that primitive ruler of Mayax. In my work, the "Vestiges of the Mayas," I have shown that the Egyptian god Osiris was no other than the Mayax prince and warrior Coh deified. The Egyptians called his father *Seb* or *Kabak*, the same name that the city still bears.

In presence of all these *facts*, that certainly cannot be mere coincidences, can we not affirm that the edifices of that city, as those of Uxmal and other Maya cities, whose ruins are to-day the most precious jewels of Yucatan, and contain such interesting historical data on the primitive traditions of mankind, date from an epoch anterior to the seventh century of the era vulgar? Observe that the Egyptian characters found in the inscriptions carved on the walls of *Kabah* and the other cities of Mayax were no longer in use in Egypt itself in the seventh century of our era, replaced as they were, at the introduction of Christianity in that country, by the letters of the Greek alphabet. How then explain their use in comparatively modern times by the Maya hierogrammatists? What shall we do about the Maya MS. that Don Juan Pio Perez has preserved, and which has been published with an English translation by Stephens in his second volume of "Incidents of Travel in Yucatan"? This MS. informs us that the Nahuatls destroyed Chichen, capital of the Itzaes, toward the end of the second century of the Christian era, after a protracted siege. If, as Mr. Charnay pretends, the monuments of Yucatan only date back to the seventh century, how could the Nahuatl hordes destroy them in the second, and establish themselves at Uxmal, that was then a great metropolis, as the inscription on the west facade of the sanctuary in that city recites?

On the other hand, who with a fair allowance of common-sense will pretend to say that the existence of a rough sketch of a horse on the wall of an edifice proves it to be of ancient or modern construction, or even that the building was in use and inhabited at the time the drawing was made? Because the walls of the apartments in the palaces of Uxmal and Chichen are covered with the names of the persons who have visited them, and because many have written on them their more or less poetical impressions, or made rough drawings of hearts pierced with arrows and other devices, can it be affirmed that these monuments are modern, and inhabited at the time their walls were thus scrawled upon? No intelligent person will answer affirmatively.

On the other hand, had Mr. Charnay, before writing about the ruins of Yucatan, taken the trouble to inquire concerning the customs of the aborigines, some one might have told him, as he was informed in fact by the historian Bishop Don Crecencio Carillo* that those who live in the neighborhood of said monuments still go secretly, and in the small hours of the morning, to burn incense, light wax candles, and practice superstitious rites of the religion of their forefathers. Everybody knows that in the country Rev. Father Cogolludo discovered it, to his intense disgust and chagrin, according to what he himself tells us, when he visited the diviner's house at Uxmal. Had the French explorer visited the very interesting ruins of *Tulum*, on the east coast of Yucatan, he would have convinced himself that in the principal edifice wax candles are constantly burning, and often copal and other odoriferous gums; and that the inhabitants of *Tulum pueblo*, a village about three miles inland, though they do not dwell in the houses of their ancestors, come thither to worship the same gods that their fathers adored.

It is not enough to run hastily over a country to know about the customs and manners of the inhabitants, particularly when they are as secretive as the aborigines of Yucatan. It requires a long sojourn among them to be able to obtain an insight, I will not say of their traditions, but of their usages and modes of living; and to comprehend the meaning of the ornaments and devices of their edifices, and obtain an insight into the history of the builders, require a patient study of many years.

By the relation of Cogolludo, we see that in his time, as in our days, these ruined monuments served as places for worship of the inhabitants of the neighboring villages; and Bishop Landa informs us that at the time of the arrival of the Spaniard in 1517, not only were these cities abandoned and their public edifices superb ruins, but that the natives had lost all tradition as to who were their builders, although they carefully consigned all events of their history to books that he boasts of having burned; and the science of archæology formed one of the branches of learning in their colleges.

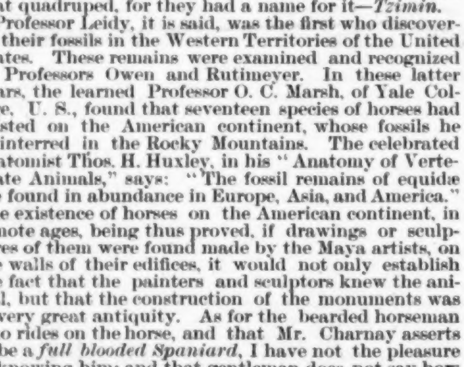
But, on the other hand, and by way of argument, conceding that the drawing of a horse had been made at the time the Spaniards arrived upon the shores of Mayab, does that argue the modern construction of the wall on which it was painted? If the image was drawn in that time, is it not to be presumed that, the building being a place where the people round about gathered with veneration, the cacique ordered to be made there the image of the new enemies that invaded their country, in order that all might know who they were, and what they looked like? Did not Moctezuma do the very same thing on the arrival of the Spaniards on the shores of his empire? And if, after the conquest, some one, carried away by his hatred of the invaders, desired to make his image disappear from the venerated place, and effaced it by covering it with a coating of lime, is there anything in that that is not natural, nay, an every-day occurrence? Did not the people of Merida, at the time of the proclamation of the independence of the country from the yoke of Spain, obliterate, impulsed by the same sentiment of hatred, the Spanish coat of arms that adorned the facade of the cathedral of Merida?

Let us go further. Let us suppose that *in lieu* of the rough sketch that Mr. Charnay pretends to have discovered, he had seen one of those beautiful bass-reliefs that so abound in Chichen, and prove how advanced were the Maya artists in the arts of sculpture and drawing. Yes, let us suppose the existence of a horse carved by the sculptors of Mayax, and mounted by a *bearded man;* would such a work prove the monument to be of modern construction? Certainly not! It would, on the contrary, show its very great antiquity; for we should have before us evidence that the artists knew the horse, as they knew the bear, as they knew the mastodon, which they worshiped.

Who to-day, of the students of the natural history of the American continent, ignores that among the animals that lived on it in remote ages were many species of horses, if indeed it be true that they were extinct at the time of the Spanish conquest, and probably many ages before? The Mayas were no doubt acquainted with that quadruped, for they had a name for it—*Tzimin*.

Professor Leidy, it is said, was the first who discovered their fossils in the Western Territories of the United States. These remains were examined and recognized by Professors Owen and Rutimeyer. In these latter years, the learned Professor O. C. Marsh, of Yale College, U. S., found that seventeen species of horses had existed on the American continent, whose fossils he disinterred in the Rocky Mountains. The celebrated anatomist Thos. H. Huxley, in his "Anatomy of Vertebrate Animals," says: "The fossil remains of equidæ are found in abundance in Europe, Asia, and America." The existence of horses on the American continent, in remote ages, being thus proved, if drawings or sculptures of them were found made by the Maya artists, on the walls of their edifices, it would not only establish the fact that the painters and sculptors knew the animal, but that the construction of the monuments was of very great antiquity. As for the bearded horseman who rides on the horse, and that Mr. Charnay asserts to be a *full blooded Spaniard*, I have not the pleasure of knowing him; and that gentleman does not say how he learned that he was a native of Spain. May be he has a way of his own for ascertaining such things?

As horses existed of old on the American continent, so also lived in Mayax men with *long beards*. Their type was very similar to that of the *Mayas* of Afghanistan, who live in villages on the north side of the river *Kabul*, and also to that of the ancient white race of Polynesia, with which they were perhaps related. Their portraits are sculptured, in magnificent bass-reliefs, on



the columns and antæ of the castle at Chichen, and on the walls of the queen's box in the gymnasium of the same city. It is therefore difficult to surmise—unless the rider of the *fiery steed* discovered by Mr. Charnay has spoken to him, and made known the name of his birthplace—how the presence of a bearded man, even on horseback, sketched on the walls of a monument of the Mayas, can be adduced as proof that their construction is of modern date, or that the ruined cities of Yucatan were inhabited at the time of the Spanish conquest, or that the bearded man represented was necessarily of Spanish race.

Besides, if we are to credit Plato's description of

* See North American Review, "Expedition among the Ruined Cities of Central America," April number, 1888.

* See Bishop Carrillo y Ancona, Ancient History of Yucatan, p. 448, note.

Atlantis, in Timæus—and there are no plausible reasons why we should not—we learn that the Atlanteans not only knew the horse, but had domesticated it and used it in peace and in war. Poseydon, the supposed King of Atlantis, was represented by the Greek mythologists in a chariot drawn by horses, and armed with a trident. Atlan, according to the author of the Troano MS., consisted of three great countries, surrounded by water, as the name indicates, that were the "lands of the west" of the Egyptians—the fatherland of their ancestors. The inhabitants of these great islands had large boats; we see them both painted and sculptured on the walls of the edifices at Chichen Itza; hence they navigated the seas that separated the islands, and passed from one to another, visiting their inhabitants. That we learn from the sculptured walls of the room at the foot of funereal monument of Prince Coh, where peoples of different types, wearing a variety of costumes, some only proper for very cold climates, are represented. Hence, again, the representation of horses on the walls of the ancient palaces of Mayax would only show their very great antiquity; but, alas! so little remains of the mural paintings, and that little so defaced, even by those who accompanied Mr. Charnay in 1882 at Chichen, that it is impossible to know if the Mayas were acquainted with the horse or not. It is a fact, however, that in no place, at least of those visited by travelers to the present day, have pictures of that animal been found; and most certainly the fragment of mural painting seen by Mr. Charnay at Kabah is not a horse, nor was ever intended by the artist to represent that friend of man.

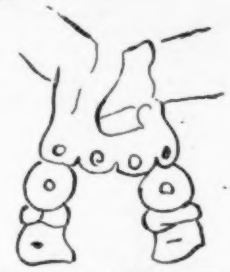
Mr. John L. Stephens, it is well known, visited the ruins of Yucatan in 1842. He was accompanied by an excellent and most conscientious artist, Mr. Catherwood. When in Kabah, they had the bush cleared from all the monuments, to be able to examine them scrupulously. He has consecrated thirty-two pages of his first volume to the prolix description of the ruins, and made pretty accurate plans of them; and the drawings of Mr. Catherwood are as correct and minute in details as man can make of such edifices and devices without the aid of the camera obscura. Undoubtedly, if the sketch of a horse mounted by a *Spanish* cavalier had existed there, they would not have failed to mention it, and present to the world a faithful representation of the same, whatever its historical or artistic merit might be. Their not doing it is *prima facie* evidence that, when these gentlemen visited the ruins, such rough sketch did not exist; or that, if some vestige of mural painting existed, as it did exist, the fragment was not sufficient *for them* to reconstruct the picture; but if the Maya artist had tried to represent a horse mounted by a bearded rider, surely Mr. Catherwood would not have failed to recognize the lines, which of necessity were more perfect than they are to-day, and Mr. Stephens to mention so important a discovery. Still Mr. Charnay announces to the world:* "It was February 2 when we reached Kabah, and hardly had we trod the ground about the ruins, when I made a discovery of very *exceptional* importance. I write these notes in a state of veritable intoxication; my joy knows no bounds, for this discovery is the most significant one ever made in American archæology. The question of American civilization is settled, and I have the satisfaction of knowing that my theory of the modern origin of those civilizations is established beyond dispute.

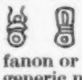
"In the middle apartment of the building called by Stephens 'Casa No. 2,' on the front wall, is seen a design which by itself alone, tells the whole story. It represents a *horse with its rider*. Horse and rider are designed after the Indian manner by an *inexperienced hand*, guided by an overexcited imagination. Yet it is impossible not to recognize both figures. The horse has his trappings; we see the stirrups; the man wears his cuirass. Unfortunately, a portion of the design is missing, and further, a coat of lime was laid over it all, which I had to remove in part, in order to make a tracing of it. . . . It is to be regretted that portions of the design are in a very bad condition. Thus, *the belly of the horse is wanting;* as also a portion of the trappings toward the hind quarters. The *heads both of cavalier and of horse are also effaced.*"

Only to the discoverer of the phantom Toltec palaces of the valley of Mexico is it given to see a horse mounted by a Spanish cavalier with his cuirass in this fragment of mural painting; and the words used to make known his pretended discovery are sufficient to indicate that he was himself *overexcited* when he traced his notes.

The intrinsic characteristics of this design show it to belong to the same school of writing as the Troano MS. It is evidently the work of artists who flourished after the invasion of the country by the Nahuatls in the year 242 of the Christian era, if we are to believe the computations of the epochs of Pio Perez MS., made by Professor Valentini. This fragment represents some *debris* of the history of the city of Kabah and that of its rulers. What remains is the head and uplifted arms of a deified personage, as indicated by the club that forms his headdress, grasping a serpent firmly with his left hand; the head of the snake is likewise a human face, not drawn by an *inexperienced hand*, but indeed by that of a clever artist. It is, in fact, a profile portrait of an individual belonging to King *Can's* family, for in it may be recognized the typical features of said family, as we see them represented in the heads that adorned the frieze near the summit of the pyramid south and adjoining the "House of the Governor" at Uxmal. One of these heads is now in the "Yucatecan Museum" in Merida, and the plaster cast of another in the "Metropolitan Museum of Art," Central Park, New York.

The ornament



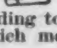
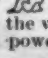
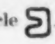
pendent from the arms, and which no doubt were taken for the legs and feet of the horse, is a kind of *fanon* often seen worn by the personages pictured in the Troano MS. These ornaments are composed of four scallops with a dot in the center of each. These stand for the numeral 4—in Maya *can*—and the signs  are the letters of the Maya alphabet, in use at the time of the Conquest, corresponding to our Latin O, according to Bishop Landa. The fanon or maniple on each arm would then mean *canob*, generic name of the dynasty of the primitive rulers of Mayax, as *khan* is that of the kings of Tartary and of the governor of a province in Persia. The male portion of the family of King *Can* was composed of four individuals—himself and his three sons, *Cay*, *Aac*, and *Coh*, whose statue I have exhumed at Chichen, as that of Cay at Uxmal.

In order to comprehend the fragment of mural painting, it is necessary to analyze each of the parts that now remain entire:

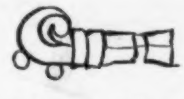
1. Is the uplifted hand of a personage holding aloft the body of a serpent, the bend grasped by the hand being symbolical of the Yucatecan peninsula.
2. Body of the serpent bearing marks identical to those seen on the body of the serpent symbolical of the empire of Mayax, represented on plates xxvi. and xxvii. of the second part of the Troano MS.
3. Head of the serpent. This being reversed

presents the profile of a human head, typical of the features of the *Can* family.

4. Forearm and bracelet.
5. Fanon or maniple hanging over the bend of the arm.
6. Arm.
7. Seemingly grotesque head of the personage.

This head is composed of characters of the Maya alphabet; thus  *cimi*, equivalent to *k* or *c*,  *a*, and *n*, according to Bishop Landa, forming the vocable *can*, which means, as well as serpent, power and might. The hand that holds firmly the serpent is *kab* in Maya, but this serpent is the emblem of the Maya empire, according to the author of the Troano MS. Then this part of the mural paintings would seem to signify "The powerful hand that ruleth Mayax," or *Can Kabah*, he of the powerful hand, ruler of Mayax, *Ah* being the masculine article .

8. Is the club

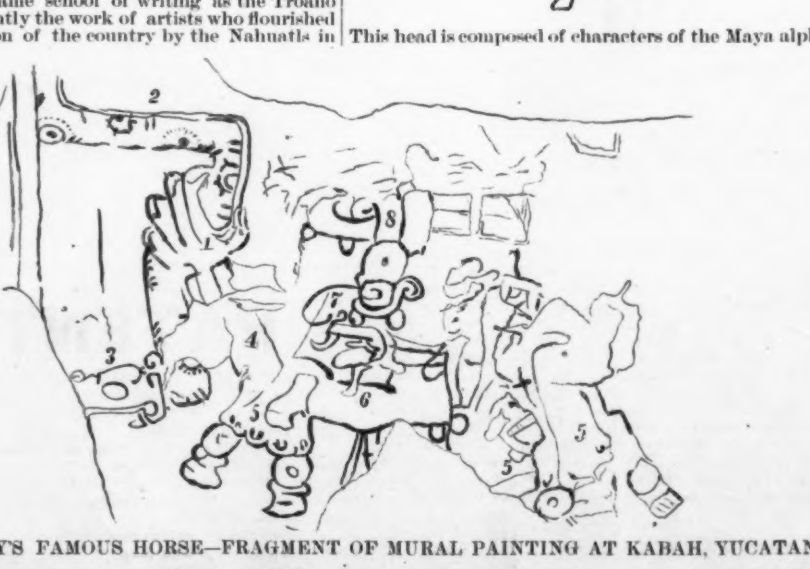


emblem of fire and water, ordinary headdress of the gods of fire and water in the Troano MS.

It is evident that many lines have been effaced in trying to clean the picture from the dust of ages, that Mr. Charnay also mistook for a coat of lime placed purposely to obliterate the picture, making of what remains of the drawing a tangle of lines now impossible to unravel. This is much to be lamented. The same deplorable error was made in Chichen, where the mural paintings on the south wall of Coh's funereal chamber have been utterly ruined by "El Consul Americano," as the Indians assured me who accompanied Mr. Charnay, by scraping the stucco to free the drawings from the dust of centuries and the dirt of bats and swallows that are now the permanent inhabitants of that grand edifice.

It is now demonstrated that the picture of a horse mounted by a Spanish rider, *so significant for the American archæology*, does not exist, in fact, on the walls of the edifices at Kabah. The date of their construction still remains an unsolved problem, notwithstanding Mr. Charnay's bold assertion to the contrary, that *the question of American civilization is now settled* by this, *his discovery of very exceptional importance.*

AUGUSTUS LE PLONGEON, M.D.



MR. CHARNAY'S FAMOUS HORSE—FRAGMENT OF MURAL PAINTING AT KABAH, YUCATAN.

* North American Review, No. cccv., April, [illegible] pp. 411-412.

THE LEAF-EATING ANT.

MR. A. NICOLS, writing to *Nature*, refers to the present treeless condition of the pampas of the La Plata and of the difficulty of establishing trees on those plains. North of Monte Video, for some hundreds of miles, the leaf-eating ant is omnipresent. I have seen streams of them running along the beaten paths to their nests, each ant carrying the yellow petals of some plant similar to the buttercup. When I first noticed, from my horse, this procession of golden leaves, I was greatly astonished. Familiarity, however, soon dispelled this. The *opima spolia* was being carried to their nests and taken under ground, no doubt as a provision for the winter. The ants were about a quarter of an inch in length, and of a beautiful steel-blue color. Those I picked up for examination demonstrated their powers by shearing off the hard cuticle of my thumb or fore-finger with their mandibles. Subsequently, I made the acquaintance of a gentleman, well known in the Banda Oriental, the owner of the "Estancia Sherenden." He showed me a splendid grove of about two acres of *Eucalypti* of several species—the "blue" and "red" gum chiefly. These he had reared from seed, their enemies being these ants. As soon as the first leaves of his cherished plants appeared, the ants cut them off. He then got a drum of gas-tar sent up from town, and made a circle round each plant. The ants objected to this, and all the trees made a start. For three years in succession he carefully painted the stems with tar, and eventually they got so far away as to be able to supply the wants of their foes and still flourish. When I saw these trees they bore finer foliage than I ever met with in the Australian bush during four years' experience. They were then eight years old. Many were forty feet high, and thirty-six inches round at some three feet from the earth.

DO PLANTS VARY WHEN PROPAGATED BY CUTTINGS?

By PETER HENDERSON.

ON reading what is said about "seed" potatoes in last week's *Press*, I notice the assertion is made that "seed" taken from the most productive hills gave a larger yield of tubers than that taken from the least productive. I am inclined to believe that further experiments will show that this increased productiveness will not continue to hold, because the reason for the greater or less yield was probably only an accident of circumstances, especially favorable conditions of the set made to form the hill, or by being highly fertilized, or some such cause that gave it this temporary advantage; and that the chances are all against any permanent improvement being made by such selections.

The potato is said to have been introduced into Europe in 1584. If the original tubers had had the highest cultivation that the skill of man could give, it is exceedingly doubtful if 300 years of culture would have changed them in the slightest degree if propagation had been solely from the tubers and not from seed proper.

I base this opinion on a very extended experience in the cultivation of plants from cuttings. Strawberry plants taken from any well known kind, such as Sharpless, for example, from strong, vigorous growing plants, will certainly give better results than from weak plants of the same kind, planted in the same soil. But if the progeny of the strong and the weak plants are again taken and replanted, the difference between the two would hardly be perceptible after they had been growing together under the same conditions. Every now and then we hear of varieties of fruits or flowers, said to be degenerating, that are propagated from cuttings, grafts, or roots. I believe there is no such thing as permanent degeneration of any fruit, flower, or vegetable that is raised from cuttings, grafts, or roots. The Jargonelle pear, the Ribston Pippin apple, the Hamburg grape, or the Kean's Seedling strawberry of the English gardens are found to look just as good, and as bad, under different conditions of culture as they were fifty or one hundred years ago, and that any change, either better or worse, is only an accident of circumstances, and temporary. For be it remembered that when a plant is raised from cuttings as in the grape vine, grafts as in a pear, or layers as in a strawberry, or pieces of the root as in a potato, such parts

are not seed proper, but are merely parts of the same individual first called into existence. The Early Rose potato, introduced nearly a quarter of a century ago, is just as good to-day, under proper cultivation, as when first introduced, but is certainly no better. It is often to be found, of course, under unfavorable circumstances, and then may be supposed to have degenerated; but when it is shown under other circumstances to be as fine as when first introduced, how can the assertion of permanent degeneracy be admitted?

Permanent improvement, in my opinion, in varieties can only be made by the selection of the fittest specimens that have been raised from seed proper. Here we have, as in the Early Rose potato, the Sharpless strawberry, and the Concord grape, varieties that have shot ahead of their fellows, having merits that the general public recognize, but all the art of man cannot further improve these so that their "progeny" (to use a convenient, though, perhaps, not a strictly correct term) will be permanently better or worse than when first called into existence. It is a very common error, when a luxuriant crop of anything is seen growing under specially good culture, to imagine that cuttings, roots, or seeds from such plants must necessarily give similar results when the same conditions to grow such crops well are not present. Not long ago Boston was famed for its rosebuds, and even experienced florists paid double price for stock from such plants, only to find that in their hands these plants would not produce Boston rosebuds. Now the case is changed. Madison, N. J., as a whole, beats Boston in rose culture, and the demand has changed from Boston to Madison, and, of course, with the same results; for, if the purchasers of Madison roses cannot give Madison culture, there will be no Madison rosebuds. While we admit the advantage of a healthy stock, and even, perhaps, the value of a change of stock, what I claim is that no culture will permanently change the variety from the normal condition, and that the only advance that can be made is by selecting the best specimens, hybridizing these from their seed, again selecting, and so on forward.

To be sure, we have in rare instances what are known as "sports" by gardeners, or what Darwin has called "bud variation," which may be improvements on the original variety or the reverse; but culture, good or bad, has nothing to do with such anomalous cases.

Again and again we see it asserted as a matter for wonder that the wild celery of English marshes or the wild carrot of the hedge rows have attained their present high condition by "cultivation." If cultivation means that man has through generations "selected the fittest" of these again and again, taking always the flower of the flock, so as to have attained the present perfection, then that is true; but if by "cultivation" is meant that "domestication" by high culture, manuring, etc., in a garden or a field has caused such results, then, in my humble opinion, is not true.—*Phila. Press.*

PINUS LAMBERTIANA.

THE accompanying sketch is an attempt to convey an idea of the port and aspect of a P. Lambertiana (the sugar pine) about 230 feet high, as seen from a distance of a quarter of a mile or so. In so far as it shows a straight trunk, a very lanky contour, and a sparse ramification, it may convey a fair impression of that stupendous tree, which from a distance wants the picturesqueness of P. ponderosa, the bulk in proportion to height of a Sequoia, and the beautiful green color of the P. concolor. In one striking character, however, it surpasses these and all other pines known to me, and that is in the size and exceeding beauty of the living cones. It is impossible to give any idea in a reduced figure such as that of this woodcut of the appearance of these as they hang on the tree, without grossly exaggerating them; the simple reason being that the observer must be near a tree of such proportions to see them at all, and then only a small portion of the trunk and branches comes within the area of vision. Then, indeed, the effect of these huge cones, which are, on the average, 12 to 18 inches long, and hang from the very tips of the branches, is strikingly beautiful, especially in sunshine, when they sparkle like pendants of diamonds, owing to the high refractive power of the resin that copiously exudes from them and hangs in drops to the scales.

The history of the discovery of P. Lambertiana by Douglas is too well known to require a notice here. It is one of the two Western United States representatives of the Weymouth pine, P. Strobus, of the Eastern States, the other being its near ally, P. monticola, and it is not always easy to distinguish young specimens of these three in European arboreta. In point of color the Lambert and Weymouth are both dark, and the common form of monticola is a light green, but there is a dark variety of the latter. A better character is the more drooping attitude of the tassels of leaves toward the under side of the branches of the Lambert pine near their tips, which is a very obvious distinction when the plants are side by side, but is difficult to carry away in one's memory. The cones, of course, distinguish them, but, singularly enough, all those which I have seen of the Lambert developed in England are as small as those of the Weymouth, though not so slender. Engelmann distinguishes it from all its allies by a minute anatomical character, there being an abundance of strengthening cells under the epidermis and around the ducts of the leaf. These anatomical characters, however, have not proved so constant in other species as they were supposed to be, and will want extended observation previous to confirmation.

The timber of the Lambert pine is described by Professor Sargent as heavier, coarser, stronger-grained, and probably less easily worked than that of the Eastern white pine, P. Strobus. Its meridional range is very extensive, but its latitudinal one is restricted. Commencing in the North, in the mountains south of the Columbia River, lat. 45° N., it runs along first the Cascades and then the coast ranges to 33° S., and along the Sierra Nevada throughout the length of the State of California. Its nearest Rocky Mountain ally is P. flexilis; in Mexico it is replaced by P. Ayacahuite and P. Buonapartea; in the Old World, proceeding westward, P. parviflora is its comparatively insignificant representative in Japan; in the Himalayas P. excelsa takes its place, and resembles it much more closely; it extends into Afghanistan; and, lastly, this form of Pinus terminates in the isolated P. Peuke of a few mountains of Macedonia, which has the cones of P. excelsa and the habit and dark color of P. Strobus and Lambertiana.

The specimen here drawn grew near the hotel at Calaveras, and within a short distance of the grove of Wellingtonias.—*J. D. Hooker, The Gardeners' Chronicle.*

GROWTH OF WEEDS ON SHIPS.

THE engineers of the Indian troopship Serapis had complained that on the last passage to and from Bombay they were not able to maintain the regulation speed of ten knots without driving the engines at full power, and the question arose whether the falling off in speed was due, as the shipwright department contended, to some defect in the propeller, or, as the dockyard engineers maintained, to the foul condition of the ship's hull. Previous to leaving for India, in September last, she was tried on the measured mile, when a speed of 12 knots was realized. This was not deemed satisfactory, and the comparatively low speed was attributed by those in charge of the trial to the fact that six weeks had elapsed since she came out of dock. On her return to Portsmouth her screw was examined by Mr. Bannister, but without any malformation being discovered,

LAMBERT'S PINE.

From a sketch taken from a native specimen by Sir Joseph Hooker.

and a trial on February 3 was carried out without any alterations being made, the only difference in the conditions being that her hull and screw had been cleaned and repainted. Her trim was substantially the same as in September—17 feet 7 inches forward and 32 feet 2 inches aft. The ship was first tried under full power, with a mean pressure of $57\frac{1}{2}$ pounds of steam in the boilers. The revolutions were 54. The power indicated was 3,320, and the mean speed realized over 13 knots. The engines were subsequently worked with 47 revolutions—about the rate used for ordinary steaming—when 2,082 horse power was developed and a speed of 11·321 knots was obtained. The trial was thus eminently satisfactory, leaving no doubt that the falling off in speed complained of was due to the growth of weeds on the hull.

HIGH TENSION CURRENT DYNAMOS.

THE danger incurred by the use of very high tension current dynamos is certainly one of the most serious obstacles to the development of electric lighting from large central stations. A French electrician, M. D'Arsonval, Professor at the College de France, has recently (Jan. 26) communicated a paper to the Academy of Sciences, in which he describes how he has been enabled to render the employment of such machines absolutely free from danger. He introduces the subject by the often repeated remark, that it is not so much the current itself which is the source of peril as the counter current, set up at the moment of breaking or making contact. It is on this account that with equal tension, alternating currents, which are only currents of opposite values, succeeding each other suddenly, produce physiological effects vastly more energetic than continuous currents. M. D'Arsonval concludes from this, that batteries and dynamos giving currents of equal tension and equal strength may be very unequally dangerous, and that even a current that may be dangerous in one circuit need not be so in another. To do away with all risk, it is sufficient to prevent the extra current to traverse the body of the experimenter, and to do this it is only necessary to place in connection with the terminals of the dynamo a series of small voltameters with lead plates and acidulated water, in sufficient number that the electromotive force of polarization may be greater than the electromotive force of the machine. This arrangement is claimed to set up an absolute barrier for the direct current, while the extra current passes freely. At the moment when the circuit is broken the extra current traverses the voltameters, and the safety of the experimenter is guaranteed. The efficiency of this method can be very easily tested.

A CATALOGUE containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.
